Eating Disorders and Interoception: A Systematic Review and Meta-Analysis

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This report is submitted in partial fulfillment of the degree of Master of Psychology (Clinical)

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Declaration

This dissertation contains no material which has been accepted for the award of any other degree or diploma in any University, and, to the best of my knowledge, contains no materials previously published except where due reference is made.

I give permission for the digital version of my dissertation to be made available on the web, via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the School to restrict access for a period of time.

Isabella Ferraro

November 2023

Statement of Contribution

I.F. and A.T. collaborated to review the literature and devise the project, including the main conceptual ideas, design framework, and protocol development. I.F carried out data collection, synthesis, and analysis and interpretation of results with guidance from A.T.. I.F. wrote the original draft of this manuscript and A.T provided review, feedback, and editing of the manuscript that was subsequently amended by I.F.

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I would also like to thank [redacted] for contributing to the assessment of study selection bias and [redacted] for assisting with data analyses. Your contributions helped to make this project possible, and I am deeply appreciative of the time you both gave. Thanks also to [redacted] for your assistance in developing and reviewing the logic grids for each database.

Lastly, to my family and friends, thank you for being an unwavering source of love and support. The extra encouragement and support you extended to me throughout this year was invaluable.

Title Page

Article Title: Eating Disorders and Interoception: A Systematic Review and Meta-Analysis

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Author Note: This article is intended for submission to the International Journal of Eating Disorders (IJED), which adheres to the Free Format (i.e., author preferred) reference style. At present, the article has been written to the Master of Psychology (Clinical) Research Report requirement of 6,000 to 8,000 words but will be edited prior to submission to meet the 7,500 word limit specified by the IJED.

Abstract

Objective: Eating disorders (EDs) are complex psychiatric conditions characterised by an array of disordered attitudes and behaviours. Interoceptive deficits have been proposed as a transdiagnostic mechanism underlying ED development and maintenance. The present systematic review and meta-analysis sought to clarify the nature of interoceptive disturbance in EDs and identify which interoceptive domains and ED subtypes are most pertinent for understanding the relationship. **Method**: Following PRISMA guidelines, a systematic search of CINAHL, Embase, Emcare, PsycINFO, PubMed, and Web of Science was conducted. To be considered eligible for analyses, studies needed to report on validated measures of interoception for eating disordered (clinician diagnosed) and healthy control (HC; no ED diagnosis) groups. The methodological and reporting quality of each study was assessed. **Results**: Effect size data from 48 quantitative studies comprising a pooled sample of 2,870 ED and 2,144 HC participants were extracted and analysed using Comprehensive Meta Analysis software. Potential moderators were assessed using subgroup analyses and meta-regressions. Results highlighted the presence of interoceptive deficits in EDs which were greater for individuals with bulimia nervosa compared to other ED subgroups, and for interoceptive sensibility compared to interoceptive accuracy. These findings were robust, with no moderating effect shown for any of the demographic or illness related variables assessed. **Discussion**: Findings confirm the presence of a significant interoceptive deficit in EDs. This may advance our understanding of treatment approaches for EDs and how interoceptive-based interventions may improve ED symptomatology. Addressing the enduring research gaps and utilising more reliable and precise measures of interoception may allow for a more refined perspective on interoception and EDs. **Public Significance Statement:** Identifying effective treatment options for EDs is essential given their increasing prevalence and degree of treatment resistance. This study suggests that interoception appears relevant across the

spectrum of EDs and that developing and evaluating interventions that enhance interoceptive ability is a much-needed avenue for future research.

Keywords: eating disorders, disordered eating, anorexia nervosa, bulimia nervosa, binge eating disorder, other specified feeding and eating disorders, interoception, interoceptive awareness, interoceptive accuracy, interoceptive sensibility

1. INTRODUCTION

1.1 Eating Disorders

Eating disorders (EDs) are a complex psychiatric condition characterised by disturbed eating behaviours and an over-evaluation of and intense preoccupation with weight and shape, resulting in significant impairment of physiological and psychological functioning (Jenkinson et al., 2018). There are four main ED subtypes classified within the Diagnostic and Statistical Manual of Mental Disorders, (DSM-5-TR; American Psychiatric Association (APA), 2022). Anorexia Nervosa (AN) is defined by a restriction of energy intake and significantly low body weight relative to an individual's physiological requirements that is motivated by an acute fear of weight gain (APA, 2022; Phillipou et al., 2022). Bulimia Nervosa (BN) involves recurrent episodes of objective binge eating accompanied by subsequent compensatory behaviours to avoid weight gain, such as purging, fasting, or excessive exercise. During binge episodes, the individual experiences a sense of uncontrollability regarding their consumption, thereby engages in compensation to regain a sense of control over their weight and shape (APA, 2022; Herbert, 2020). Binge Eating Disorder (BED) is characterised by recurrent episodes of uncontrolled objective binge eating within a discrete time period. Bingeing is associated with features including rapid food consumption, eating in the absence of physical hunger, and experiencing a sense of embarrassment, disgust, or guilt related to the amount of food consumed (APA, 2022). Finally, Other Specified Feeding and Eating Disorders (OSFED; previously Eating Disorder Not Otherwise Specified (EDNOS)) is a diagnostic category that encompasses individuals who engage in disordered eating in a manner that results in clinically significant distress or impairment but does not fulfil diagnostic criteria for another feeding or eating disorder (Jenkinson et al., 2018). The interplay of various causal mechanisms are thought to underlie the development and maintenance of EDs. Given their increasing global prevalence and high mortality rate, coupled with degree of treatment-

resistance and high rate of relapse (Halmi, 2013; Hay et al., 2023), understanding such mechanisms and subsequent targets for intervention remains a focal point of research.

1.2 Interoception

Interoception, a construct denoting the sensation, processing, and interpretation of internal signalling by the nervous system for physiological functions including temperature and heartbeat, has been implicated as a transdiagnostic clinical primer of EDs (Khalsa et al., 2018; Mehling et al., 2018). Disturbances in the capacity to accurately perceive internal bodily stimuli, otherwise classified as interoceptive deficits, have been documented across the spectrum of ED subtypes and are thought to contribute to body image dissatisfaction and an impaired hunger/satiety response through atypical bodily signalling (Brown et al., 2020; Herbert, 2020; Kaye et al., 2009). As a result, the eating behaviours of individuals with EDs is not sufficiently guided by internal signalling that aligns with the body's physiological requirements (Herbert & Pollatos, 2018).

Interoception has been understood as a multidimensional construct comprised of distinct, measurable domains. Garfinkel and colleagues (2015) proposed three interoceptive dimensions classified as interoceptive awareness (IA), interoceptive sensibility (IS), and interoceptive accuracy (IAcc; Garfinkel et al., 2015).

A conceptualisation of IA defined by Mehling and colleagues (2012) classified it as a metacognitive ability encompassing multidimensional body awareness that differentiates between distinct attentional modes. Given that metacognitive IA is thought to be a consciously perceived state that is accessible to self-report, the authors acknowledged that this definition aligns closely with the existing definition of IS (Mehling et al., 2018). IS reflects self-evaluation of one's ability to perceive their own interoceptive states, often captured using self-report tools and confidence ratings (e.g., visual analogue scales) of one's performance in interoceptive accuracy tasks (Garfinkel et al., 2015; Forkmann et al., 2016). A commonly

used measure of IS is the Interoceptive Awareness subscale of the Eating Disorder Inventory (Interoceptive Deficits in EDI-3; Garner et al., 1983). Though the extent to which this subscale fully captures the construct of interoception has been questioned, with its items thought to primarily reflect interpretation, rather than somatic awareness, of interoceptive deficits, it remains a popular measure in interoceptive research, particularly in relation to EDs (Jenkinson et al., 2018). Measuring body awareness is important as it has been considered adaptive due to its potential health benefits, including an enhanced recognition of subtle body cues and acceptance of unfamiliar bodily sensations (Mehling et al., 2012; Flink et al., 2009). More recently developed measures of interoception, such as the Multidimensional Assessment of Interoceptive Awareness (MAIA) have sought to better evaluate the proposed multidimensional nature of interoception. Preliminary findings from such measures suggest that specific aspects of interoception, when impaired, may be more pertinent than others for understanding ED symptomatology (Brown et al., 2020; Phillipou et al., 2022)

IAcc is an objective index of interoceptive performance, assessing an individual's ability to perceive and report on their interoceptive signals, commonly measured through cardiac or gastric sensitivity (Garfinkel et al., 2015). IAcc is high when there is correspondence between an individuals' perception of their body sensations and the data from external measures, for example electrogastrography or electrocardiogram (Garfinkel et al., 2015). In the context of EDs, studies evaluating cardiac IAcc using a heartbeat detection task (HCT) have reported mixed results, with some identifying AN samples to have a reduced ability to accurately detect their heartbeat compared to healthy controls (e.g., Pollatos et al., 2008), and others finding no difference in IAcc between eating disordered individuals (AN and BN) and healthy controls (e.g., Demartini et al., 2017, Richard et al., 2019). One explanation for these varied findings may relate to the precision of the measurement tool being utilised. Indeed, the HCT has been subjected to valid criticism regarding its suitability in objectively measuring IAcc given that results can be influenced by factors including prior

knowledge and beliefs of one's resting heart rate and the use of exteroceptive information to inform one's judgement (Desmedt, et al., 2018; Murphy et al., 2018; Ring et al., 2015; Zamariola et al., 2018).

Additionally, the interoceptive modality being assessed has been found to impact on the strength of its association with disordered eating (Martin et al., 2019). A systematic review identified that impairments in gastric interoception were most consistently associated with disordered eating, though the limitations resulting from this modality having been primarily measured using self-reported hunger/fullness indicators were acknowledged (Martin et al., 2019). Despite these considerations, there remains evidence for altered IAcc in eating disordered individuals using alternative measures such as a more recently developed heartbeat discrimination task, which operationalises IAcc using a method that seeks to reduce previously identified confounds related to the HCT (Young et al., 2017).

The distinct nature of each interoceptive dimension has been evidenced through their differential association with EDs, which highlights that the subjective experience of interoception does not always coincide with objectively measured interoceptive accuracy (Herbert & Pollatos, 2018). Indeed, studies have reported differing results, with some finding a positive association between both reduced IAcc and IS in a AN sample (Pollatos et al., 2014), and others identifying that normal heartbeat detection was associated with reduced IS in eating disordered (AN and BN) samples (Ambrosecchia et al., 2017; Pollatos & Georgiou, 2016). This dissociation is thought to occur from a failure to integrate and update top-down prior beliefs and expectations to align with bottom-up physiological processes (e.g., gut-brain signalling in EDs) to form a cohesive interoceptive experience (Barca & Pezzulo, 2020). This gives rise to a prediction error (PE), whereby the actual state of the body based on interoceptive signalling is mismatched with the predicted or expected state (Herbert et al., 2020; Young et al., 2017). PE's have been shown to have an inverse relationship with IAcc, whereby larger prediction errors occur in individuals with lower objective interoceptive

accuracy (Garfinkel et al., 2016). This is due to incoming interoceptive signalling from within the body being subjectively judged as unreliable and thus prone to misinterpretation (Herbert, 2020). In the context of EDs, this process is thought to be a factor that may contribute to the precipitation or cultivation of abnormal eating behaviours (Khalsa et al., 2015). The less precise that bottom-up processes are perceived to be, the more top-down processes will dominate decision making around food consumption (Herbert, 2020). Indeed, greater top-down cognitive control has been associated with greater engagement in inhibitory behaviours, as with eating restriction in AN, whereas impaired top-down control has been observed in BN and BED due to being less able to inhibit behaviours, as evidenced by the 'loss of control' experience that characterises these subtypes (Herbert & Pollatos, 2018). Commenting on the prediction error provides insight into why interoceptive dimensions can have a differential impact across EDs, indicating that further exploration of the nature of interoceptive deficits across dimensions for different ED subtypes is warranted.

1.3 Research Gaps

Jenkinson and colleagues (2018) published a meta-analysis comprised of 29 studies and 41 samples that used the EDI to explore self-reported interoceptive deficits in individuals with or recovered from an ED. This study identified a significant interoceptive deficit within the ED sample compared to control participants, equating to an 87% chance that any given individual from the ED sample would exhibit a greater interoceptive deficit than an individual from the HC sample (Jenkinson et al., 2018). Within the ED sample, interoceptive deficits were more pronounced in participants of a younger age, lower BMI, and with diagnoses of AN or BN. However, the authors identified a limited number of studies that utilised objective measures to examine interoceptive ability (i.e., IAcc). Subsequently, they were unable to include such data in the meta-analysis to draw meaningful comparisons across interoceptive domains to determine which are most pertinent for understanding EDs (Jenkinson et al.,

2018). Additionally, Jenkinson and colleagues (2018) detected limited EDNOS (n = 3), BED (n = 5), and recovered (n = 2) ED samples, therefore could not accurately report on the pathogenesis of these EDs. Similarly, they detected an under-reporting or omission in the literature of clinical information pertaining to BMI and illness duration for ED subtypes, such that meta-regressions were unable to be performed to analyse the potential moderating role of these variables in the relationship between ED subtypes and interoceptive deficits (Jenkinson et al., 2018). Clarifying the nature of interoceptive deficits across ED subtypes while accounting for variables that might moderate the extent of these associations may refine our understanding of interoceptive impairment as both a transdiagnostic mechanism and maintaining factor in EDs. Finally, the authors included a recovered ED sample in their overall meta-analysis, the addition of which having potentially confounded the results. Indeed, findings have indicated that individuals in remission from an ED may experience interoceptive deficits differently to acute clinical populations, suggesting the characteristics of these groups are distinct and therefore cannot be conflated in interoceptive research (Crucianelli et al., 2021; Lavagnino et al., 2018).

1.4 Present Study

The current systematic review and meta-analysis sought to update and clarify the findings of Jenkinson and colleagues (2018) by evaluating interoception, and the presence of interoceptive deficits, in individuals with EDs relative to healthy controls. Secondary aims pertained to expanding the focus beyond the EDI and incorporating other subjective and objective measures of interoception to better understand how different interoceptive dimensions manifest in EDs. Additionally, this study aimed to assess interoceptive deficits across ED subtypes, particularly to enhance understanding of the nature of interoception in BED and OSFED. Finally, the present study sought to discern the potential moderating role of variables including age, BMI, illness onset, and illness duration as they respectively relate to interoception in EDs. Given that the inclusion of a recovered ED sample may have impacted

the validity of the results in Jenkinson et al. (2018), eligibility criteria in the present study was narrowed to only include studies that explicitly reported that the ED sample was diagnosed by a qualified clinician or trained researcher using DSM or ICD diagnostic criteria. This specification was employed in an attempt to minimise the potentially confounding impact of including participants with recovered, self-reported, or misdiagnosed EDs, thereby bolstering the clinical relevance of the results.

2. METHODS

This systematic review and meta-analysis was completed in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). The review protocol was pre-registered with the International Prospective Register Of Systematic Reviews (PROSPERO; CRD42021286754).

2.1 Search Strategy

Six electronic databases (CINAHL, Embase, Emcare, PsycINFO, PubMed, and Web of Science) were searched in February 2023 using a comprehensive list of search terms that were developed in consultation with a senior research librarian. Search terms were modified to align with each database interface and included a combination of keywords that captured both the population (e.g., "eating disorder", "disordered eating") and outcome of interest (e.g., "interoception", "internal states"; see Appendix B for full list of search terms). Citation alerts were constructed to capture relevant studies that were published after the initial search was conducted. These alerts operated until July 2023 and yielded one additional eligible study.

2.2 Selection Criteria

Studies were included in the present review if they met the following criteria: (a) peer-reviewed; (b) employed a quantitative or mixed-methods design (provided the quantitative data was reported separately); (c) participants were diagnosed with an ED by a qualified clinician or trained researcher using standardised criteria (i.e., DSM or ICD; APA, 2022; World Health Organisation, 2021; (d) healthy control population for comparison, with clear delineation of clinical and control groups; (e) validated measure of interoception; and (f) studies reporting sample size and mean and SD scores on measures of interoception for clinical and control groups. Studies were excluded if they (a) were not published in English; (b) had not gone through a formal peer-review process (e.g., books, theses, dissertations,

opinion pieces, and meeting abstracts); or (c) summarised primary studies, such as systematic reviews.

2.3 Data Collection

The study screening and selection process is described in a PRISMA flowchart (Figure 1; Page et al., 2021. Study screening was managed using Covidence systematic review software (Veritas Health Innovation). Title and abstract screening, full-text screening, and data extraction were conducted by one reviewer. A second, independent reviewer (postgraduate psychology student) screened a random subsample of studies ($N = 50$) based on title and abstract to confirm consistent application of the eligibility criteria and to detect selection bias. Initial inter-rater agreement was 62%, however it was revealed that the discrepancy was largely attributed to the second reviewer applying a more stringent criteria for eligibility than was required. Following discussion, this was amended and full consensus was reached (i.e., 100% inter-rater agreement).

2.4 Data Extraction

A purpose-designed data extraction sheet was used to manually extract the following information from each eligible study: title, author/s, publication year, country of study, sample size for clinical and control groups, participant characteristics (i.e., age, gender, BMI, ED diagnosis, illness onset (age), illness duration (years), comorbidities), measure of interoception, relevant effect size details (i.e., means and SDs) of the outcome measure (interoception,) and a summary of key findings (see Appendix F for complete data extraction table). Where any extraction data were unavailable, an attempt was made to contact the corresponding author to request additional information. Of the thirteen contact attempts that were made, two authors provided relevant data.

The data for three studies required recalculation prior to analysis. Aguera et al. (2019) reported means and SDs separately for males and females. These data were combined to

produce a single mean and SD score for the clinical and control groups respectively. Next, Meneguzzo et al. (2022) reported means and SDs separately for AN-restricting and AN-binge-purge subtypes. These data were combined to produce a single mean and SD score and reclassified as a general AN clinical sample. Finally, Ambrosecchia et al. (2017) reported mean and standard error (SE) for interoceptive outcomes. To remedy this and ensure consistency in effect size indices, the standard deviation was calculated by multiplying the standard error by the square root of the sample size.

2.5 Data Analysis

Meta-analyses were performed in Comprehensive Meta-Analysis Version 4 (CMA 4; Borenstein et al., 2022). Given the current study did not have to correct for small sample size bias within studies, Standardised Mean Difference (Cohen's *d*) effect sizes and their associated 95% confidence interval (95% CI) for precision and *p* values for statistical significance were calculated using a random-effects model. Where relevant data were available, effect sizes were pooled to provide a summary estimate of the overall difference in interoceptive deficits for clinical compared to control pooled samples, as well as for the differing dimensions of interoception associated with ED risk (i.e., IS, IAcc, IA). The main analyses used the study as the unit of analysis so no study contributed more than one effect size to any pooled estimates.

Effect sizes were interpreted according to Cohen's (1992) guidelines, whereby values of 0.2, 0.5, and 0.8 reflected small, medium, and large intervention effects, respectively. The effect direction was standardised so that positive values indicated greater interoceptive deficits. For ease of interpretation, the Common Language Effect Size approach was additionally adopted, whereby the effect size is converted into a percentage to quantify the probability that any given individual selected from one group (e.g., ED group) will have a higher observed score than an individual selected from another group (e.g., HC group;

McGraw & Wong, 1992). The following percentiles were assigned to the effect size values: 0.2 = 56%, 0.5 = 64%, 0.8 = 71%. For example, an effect size of 0.2 would indicate a 56% chance that a randomly selected individual from the ED group would have a greater interoceptive deficit than an individual randomly selected from the HC group.

Heterogeneity was first assessed using the Q-statistic (Q), a test of the null hypothesis that all studies contained in the analysis share a common effect size (Borenstein et al., 2021). The null hypothesis can be rejected if there is a significant p-value for Q (i.e., $p < .05$). Heterogeneity was additionally interpreted using Tau (τ), the standard deviation of the mean effect, and the I^2 statistic, which indicates the proportion of variance in observed effects that is accounted by true effects compared to sampling error (Borenstein et al., 2021). Higher I^2 reflects greater between-study variance (Higgins, 2003). Prediction intervals were additionally calculated to estimate dispersion (i.e., how widely an effect varies across included studies).

2.6 Study Quality Assessment

The methodological reporting quality of each included study was assessed by one reviewer using the QualSyst tool derived from the Standard Quality Assessment Criteria for Evaluating Primary Research Papers from a Variety of Fields guidelines (Kmet et al., 2004). QualSyst is a systematic empirical tool for critically appraising the quality of research studies. The present study adopted the system for assessing quantitative studies, which utilises 14 pre-specified criteria (see Appendix D) that are scored based on whether the item was met within each respective study ("yes" = 2, "partial" = 1, "no" = 0; Kmet et al., 2004). Three criteria were relevant to intervention studies only, so were excluded from the assessment, resulting in 11 remaining criteria for each study to be rated against. A summary score for each study was calculated by summing the total score obtained across all relevant criteria and dividing this by the total possible score.

2.7 Publication Bias

A funnel plot analysis using a conventional fixed-effects model (Borenstein et al., 2021) of studies was conducted, which plots each included studies' effect size against its standard error. The more symmetrical that studies are distributed about the combined effect size, as opposed to concentrated in favour of one side of the mean, the less likely that publication bias is a concern (Egger et al., 1997).

2.8 Sensitivity and Moderator Analysis

To assess the impact of potential outliers, a sensitivity analysis was conducted, whereby a one-study removed approached was utilised to determine the impact of each included study on the pooled effect estimate (Borenstein et al., 2021). Further investigation was considered warranted if the analysis altered the magnitude of any given effect size or its associated *p*-value.

Subgroup analyses were performed using a mixed-effects model to respectively assess whether ED subtype and interoceptive modality functioned as moderators in the relationship between EDs and interoception. Meta-regressions were conducted to evaluate the potential moderating effect of age, BMI, illness onset, and illness duration on interoceptive outcomes. These covariates were deemed to have sufficient statistical power for subgroup analysis ($N_{\text{studies}} \geq 10$; Borenstein et al., 2021).

3. RESULTS

3.1 Study Selection

Results of the systematic literature search are depicted in Figure 1. The initial search yielded 4,343 results, which was reduced to 2,237 citations once duplicates were removed. Titles and abstracts were reviewed against eligibility criteria, which resulted in 1,188 publications being retained. The full-text versions of these remaining articles were retrieved and assessed for eligibility. Three studies involving non-independent (i.e., overlapping) samples were identified during screening. The study that provided the original data was retained and the remaining two studies were excluded, resulting in a total of 48 independent studies identified for inclusion.

3.2 Study Characteristics

The analysis included 48 studies and 62 samples comprised of both an ED and HC group. To minimise confounds, samples within a study were not included if participants had characteristics or diagnoses that may interact with interoception (i.e., recovered ED $N_{studies} = 5$, disordered eating behaviours (e.g., restriction or overeating) $N_{studies} = 2$, obesity $N_{studies} = 1$, depression $N_{studies} = 1$, and functional motor symptoms $N_{studies} = 1$). This resulted in a total pooled sample of 2,870 eating disorder participants and 2,144 healthy controls. ED samples were recruited from inpatient and outpatient treatment settings, while HCs were typically recruited from the community or Universities via advertisement. All studies were cross-sectional ($N_{studies} = 41$) or longitudinal ($N_{studies} = 7$) in design. Studies originated from Italy ($N_{studies} = 19$), Germany ($N_{studies} = 9$), the United States of America ($N_{studies} = 7$), China ($N_{studies} = 3$), Spain ($N_{studies} = 3$), the United Kingdom ($N_{studies} = 2$), Australia ($N_{studies} = 1$), Czechia ($N_{studies} = 1$), France ($N_{studies} = 1$), Israel ($N_{studies} = 1$), and Japan ($N_{studies} = 1$). All ED samples were diagnosed by a clinician or trained researcher according to DSM or ICD criteria. A

majority of studies evaluated interoception using a version of the EDI ($N_{studies}$ = 31), followed by the HCT ($N_{studies}$ = 8) and other measures of IS or IAcc ($N_{studies}$ = 9).

3.3 Sample Characteristics

The pooled sample of HC participants were primarily female (97.42%), with a mean age of 23.0 years (range = 15.7 – 42.1 years) and mean body mass index (BMI) of 21.62 (range = 19.0 – 34.3). The pooled sample of ED participants were primarily female (96.0%), with a mean age of 23.0 (range = 14.9 – 38.8 years) and mean BMI of 18.4 (range = 13.4 – 36.10). Studies were comprised of AN ($N_{samples}$ = 35), BN ($N_{samples}$ = 14), BED ($N_{samples}$ = 2), EDNOS ($N_{samples}$ = 2), UFED ($N_{samples}$ = 1), and mixed ED ($N_{samples}$ = 8) samples. The average age of ED onset was 15.91 (range = 13.1 – 19.98 years) and average duration of ED was 4.48 years (range = 0.33 – 11.5 years).

Figure 1

PRISMA Flowchart Outlining Study Selection Process (Page et al., 2020)

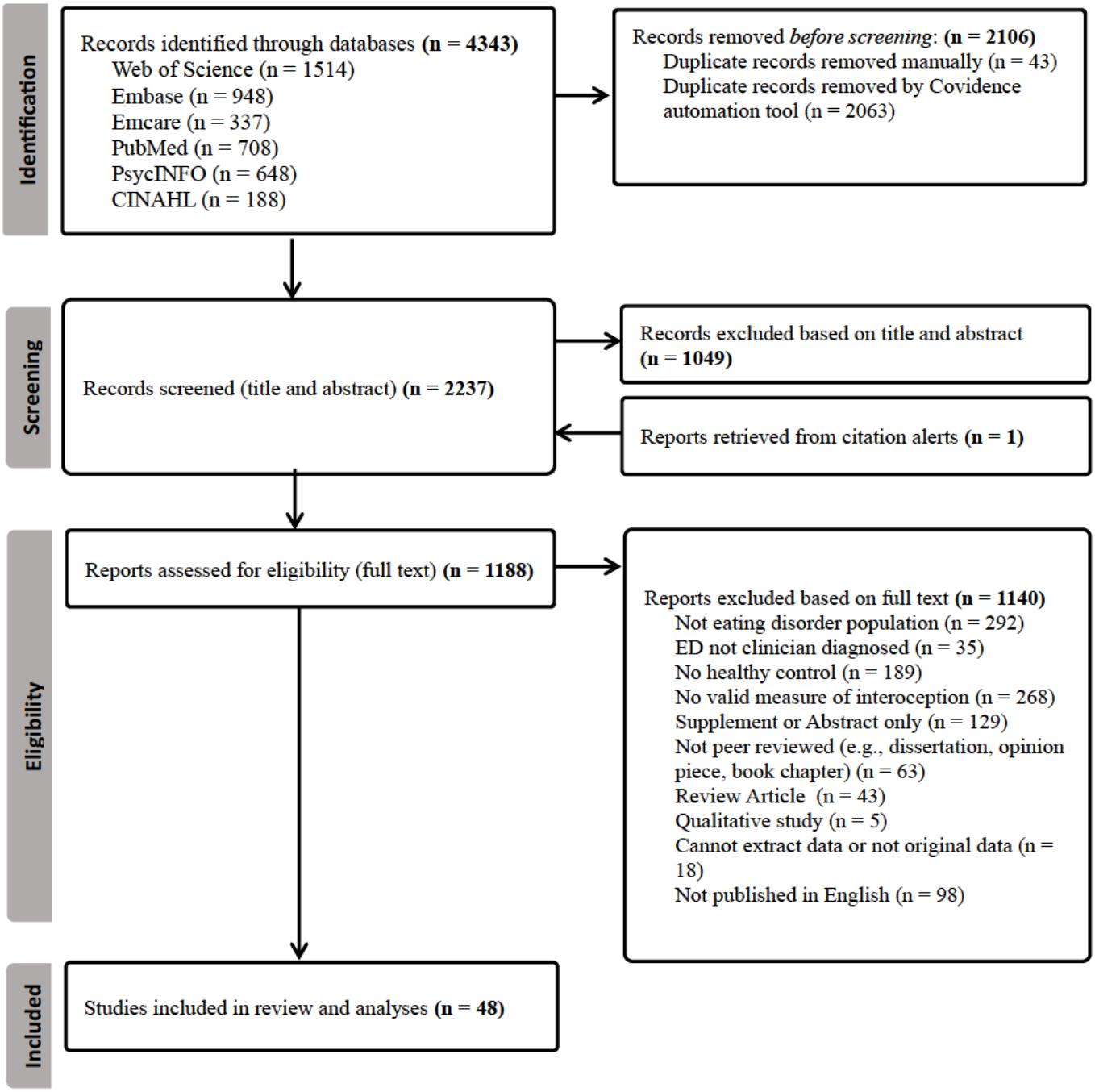


Table 1

Participant Characteristics for Pooled Sample ($N_{studies}$ = 48, N_{ED} = 2,870, N_{HC} = 2,144)

	$N_{studies}$	$N_{participants}$	%	*M*	*SD*
Age (years)					
ED	47	2,819	98.22%	23.0	4.85
HC	46	1,964	91.60%	23.0	6.08
Gender					
Female	47	4,854	96.81%	-	-
Male	47	160	3.19%	-	-
BMI					
ED	43	1,808	63.0%	18.4	4.56
HC	43	1,467	68.42%	21.62	2.33
ED Diagnosis					
AN	35	1,464	51.01%	-	-
BN	14	799	27.84%	-	-
BED	2	205	7.14%	-	-
EDNOS	2	314	1.05%	-	-
UFED	1	30	2.06%	-	-
Mixed	8	59		-	-
ED Onset (age)	16	431	15.02%	15.91	3.16
ED Duration (years)	30	1,030	35.89%	4.48	1.87

Note: ED = eating disorder; HC = healthy controls; $N_{studies}$ = number of studies providing these data; $N_{participants}$ = number of participants from studies providing these data; % = percentage of total pooled sample; *M* = mean; SD = standard deviation; BMI = body mass index; AN = anorexia nervosa; BN = bulimia nervosa; BED = binge eating disorder; EDNOS = eating disorder not otherwise specified; OSFED = other specified feeding and eating disorder; UFED = unspecified feeding and eating disorder.

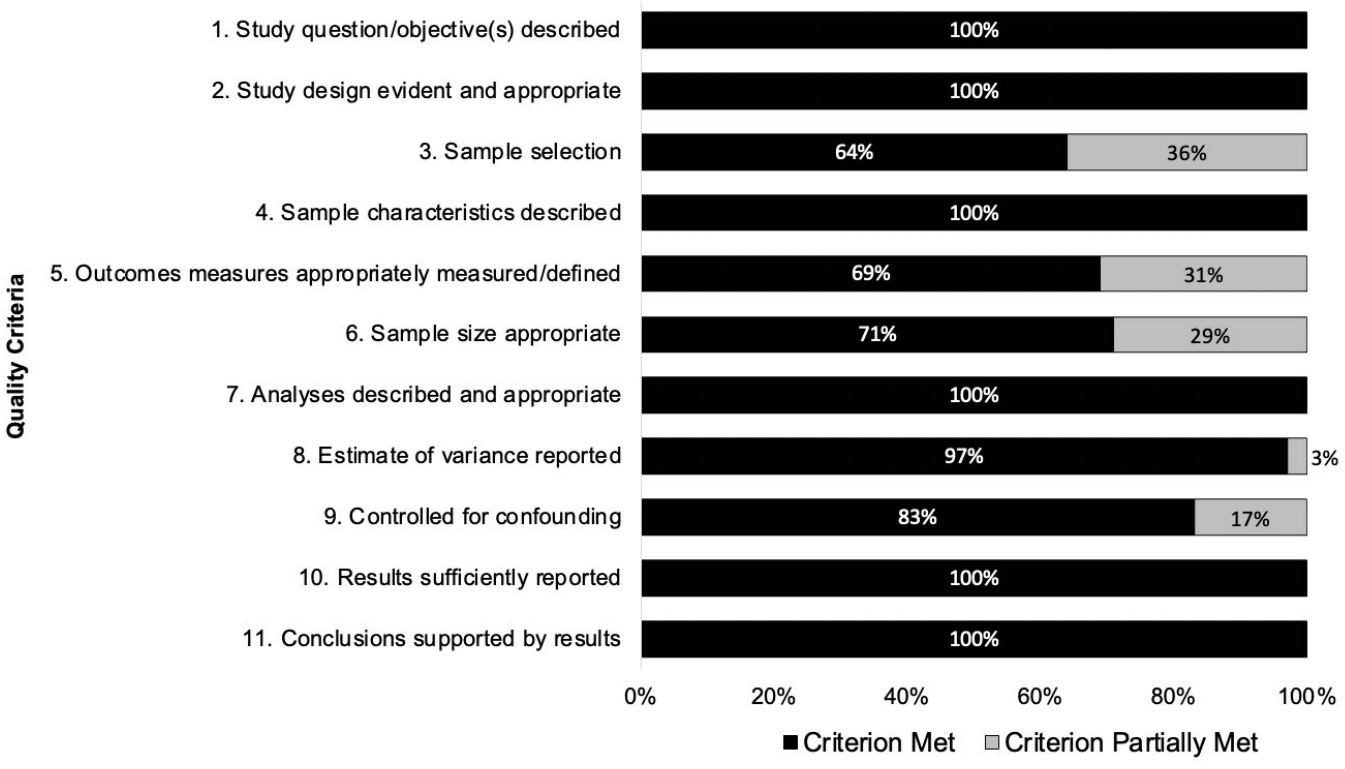
3.4 Risk of Bias Assessment

The average QualSyst score was .89 (SD = .04, range = .82 - .95; see Figure 2 and Appendix E). Therefore, all studies met the conservative threshold (i.e., 75%) for inclusion in analyses (Kmet et al., 2004). All studies provided an adequate description of their objective/s (Criterion 1), sufficiently described the study design (Criterion 2) and subject characteristics

(e.g., age, gender; Criterion 4), and appropriately outlined analytic methods (Criterion 10: 100% fulfilled respectively). A majority of studies reported an estimate of variance (e.g., range, SD; Criterion 8: 97% fulfilled). However, the recruitment procedure and methods for minimising selection bias were often unclear (Criterion 3: 64% fulfilled) and authors frequently acknowledged small sample sizes, though most studies were sufficiently powered to detect significant associations for major outcomes (Criterion 6: 71% fulfilled). Additionally, information on self-report measures often lacked sufficient information including response options and psychometric properties (Criterion 5: 69% fulfilled). Whilst several studies did not appear to control for confounding variables (Criterion 9: 83% fulfilled), it was considered that these omissions were unlikely to have impacted the reliability of the results. Overall, studies were considered to be of sound methodological and reporting quality, with quality scores indicating a low risk of bias.

Figure 2

Outcomes of the Risk of Bias Assessment using the QualSyst Tool (Kmet et al., 2004).

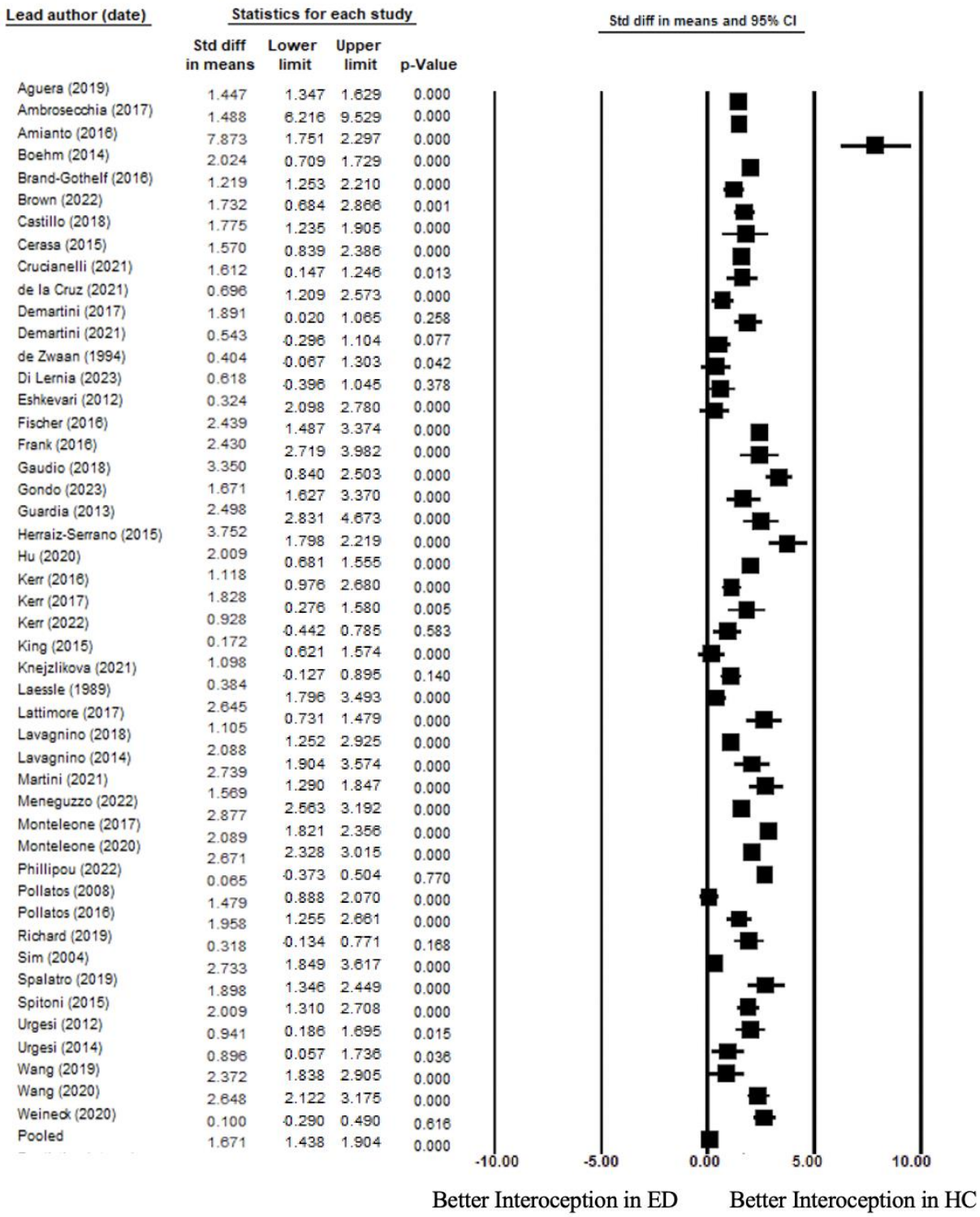


3.5 Interoceptive Deficits: Clinical versus Control

Individual and pooled effect size data for each study are listed in Table 2. Significantly greater interoceptive deficits were shown in the pooled ED sample compared with HCs (d = 1.671, 95% CI = 1.438 to 1.904, $p < .001$). 40 studies produced significant, moderate to large group differences and revealed an 84.9% chance that an individual chosen at random from the ED sample would have a greater interoceptive deficit than a person randomly selected from the HC sample. The studies were heterogenous $(Q(47) = 908.68, p < 0.001)$, with $\tau = .959$ and an I^2 value of 94.8% indicating a large amount of variance and dispersion across effect estimates that is not attributable to sampling error. Assuming normal distribution, the true effect size in 95% of comparable populations is expected to fall between the prediction interval of -0.493 to 3.413. Finally, the included studies were robust to publication bias, confirmed by funnel plot analysis (Figure 3). Additionally, Duval and Tweedie's (2000) Trim and Fill method revealed no imputed studies and nil change to the effect estimate.

Table 2

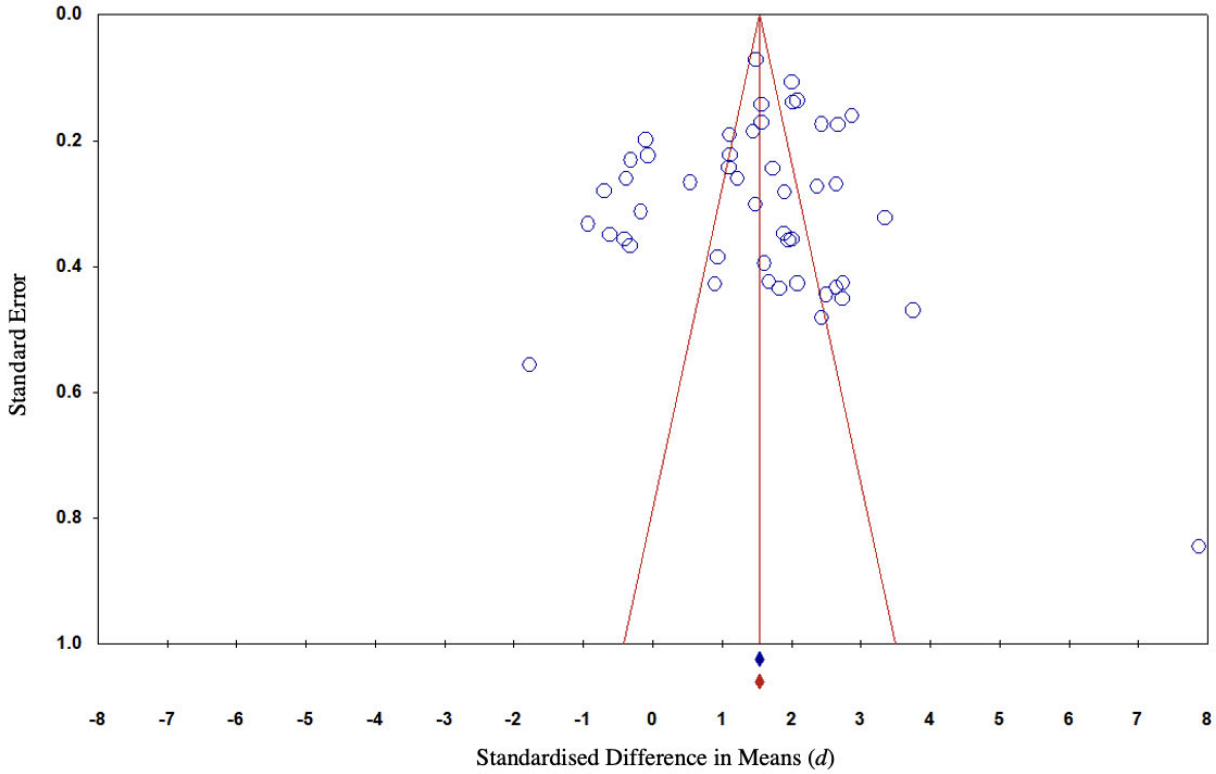
Overall Mean Group Differences with Forest Plot



Note: Std diff in means = standardised difference in means (*d*); CI = confidence interval

Figure 3

Funnel Plot of Standard Error by Standardised Difference in Means (d)



3.6 Interoceptive Deficits: ED Subtypes

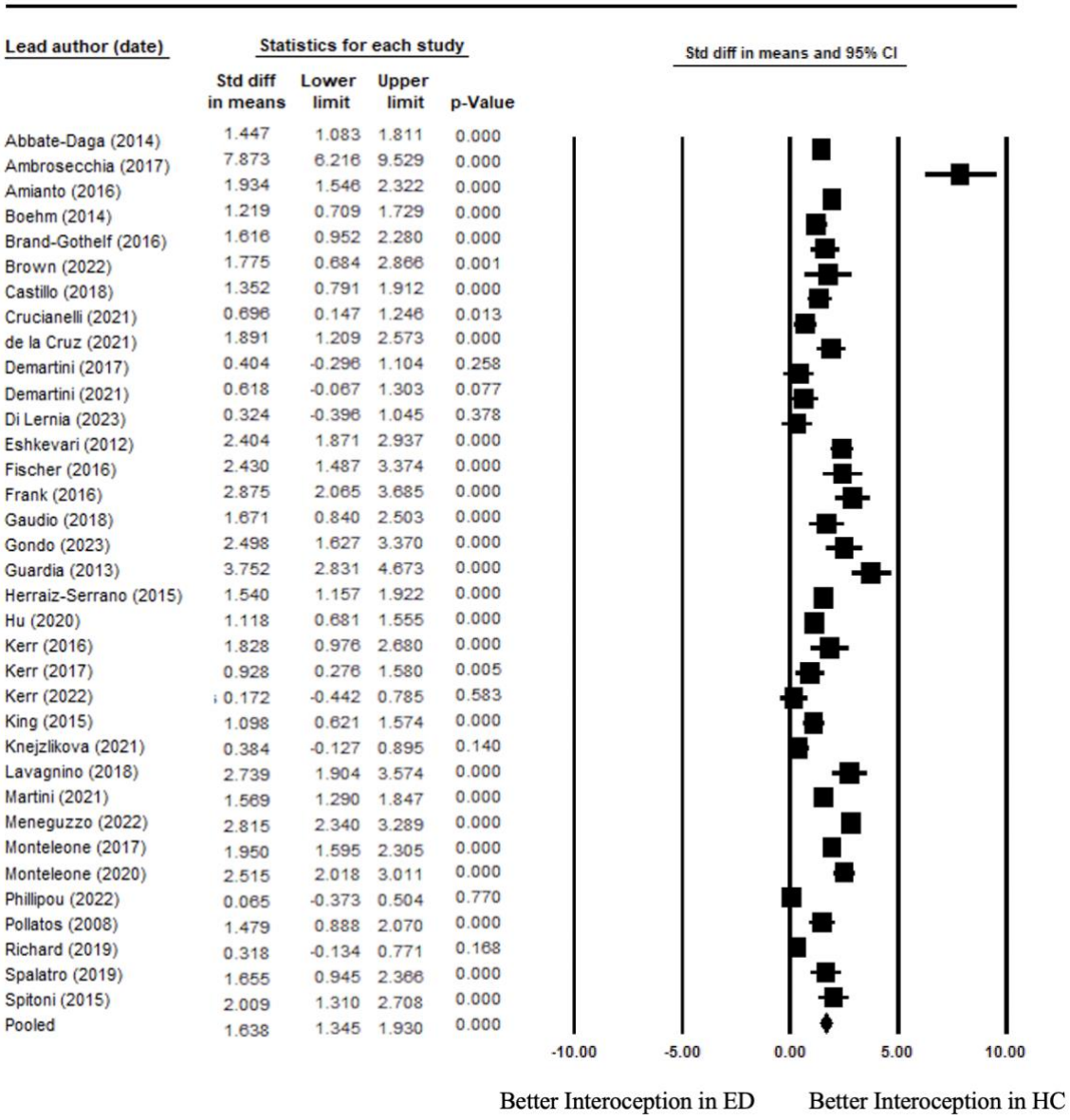
Studies were grouped by ED subtype (i.e., AN, BN, EDNOS/OSFED, UFED, and Mixed) to explore how they respectively interact with interoceptive deficits. Individual and pooled effect size data grouped by ED subtype are reported in Tables 3-5. Subgroup analysis was unable to conducted for UFED given that $N_{studies} = 1$. Moreover, given the small sample size for BED ($N_{studies} = 2$) and the significant within-study variation that could not be meaningfully pooled ($d = .543$ and $d = 2.932$, respectively), it was also excluded from analysis. Additionally, there was considerable imprecision for the pooled Mixed ED sample (CI = -0.812 to 2.021) so results were not considered meaningful to interpretation.

Of the remaining samples of AN, BN, and EDNOS/OSFED, comparisons indicated that individuals with BN reported the greatest interoceptive deficit ($d = 2.405$, 95% CI = 2.173 to 2.637, $p < .001$). The studies comprising the BN sample were heterogenous ($Q(13) = 27.93$, $p = 0.009$), with $\tau = .31$ and an I^2 value of 53.42% indicating a moderate amount of

variance and dispersion across effect estimates. Although the sample size was small, results indicated a significant interoceptive deficit in EDNOS/OSFED (d = 2.071, 95% CI = 1.773 to 2.370, p < .001). However, given the within-study variation contributing to imprecise estimates (i.e., wide CIs), this result must be interpreted with caution. Finally, a large and significant effect was found in the pooled AN sample (d = 1.638, 95% CI = 1.345 to 1.930, p < .001). The studies were heterogenous ($Q(34)$ = 595.05, p < 0.001), with τ = 1.12 and an I^2 value of 94.29% indicating a large amount of variance across effect estimates.

Table 3

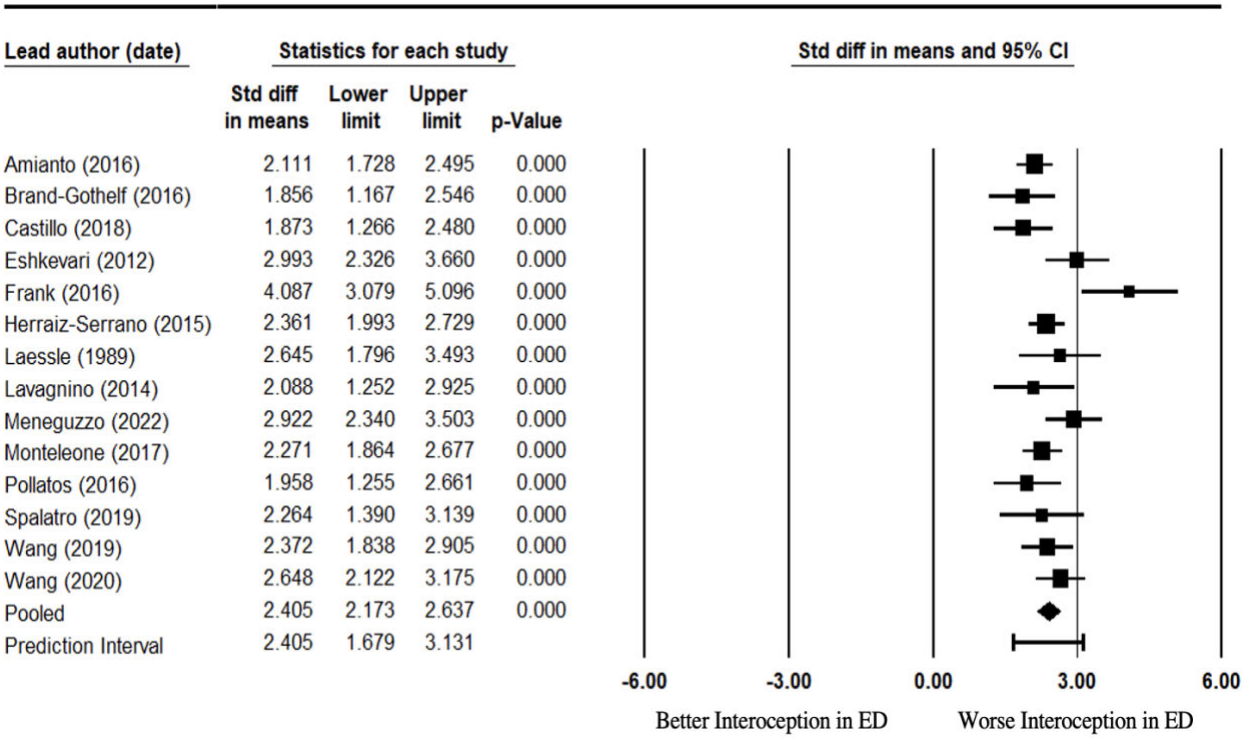
Mean Group Differences in Anorexia Nervosa with Forest Plot



Note: Std diff in means = standardised difference in means (d); CI = confidence interval

Table 4

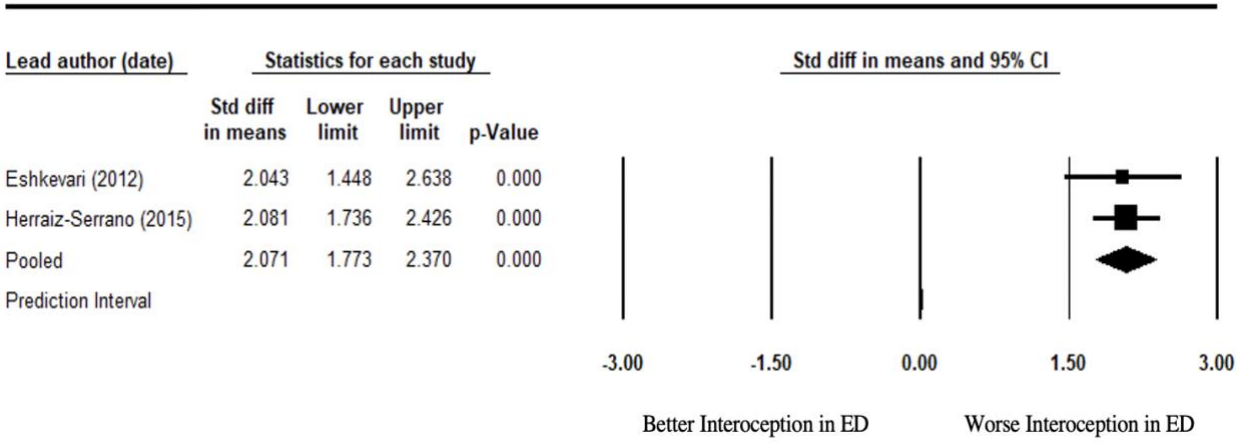
Mean Group Differences in Bulimia Nervosa with Forest Plot



Note: Std diff in means = standardised difference in means (*d*); CI = confidence interval

Table 5

Mean Group Differences in EDNOS/OSFED with Forest Plot



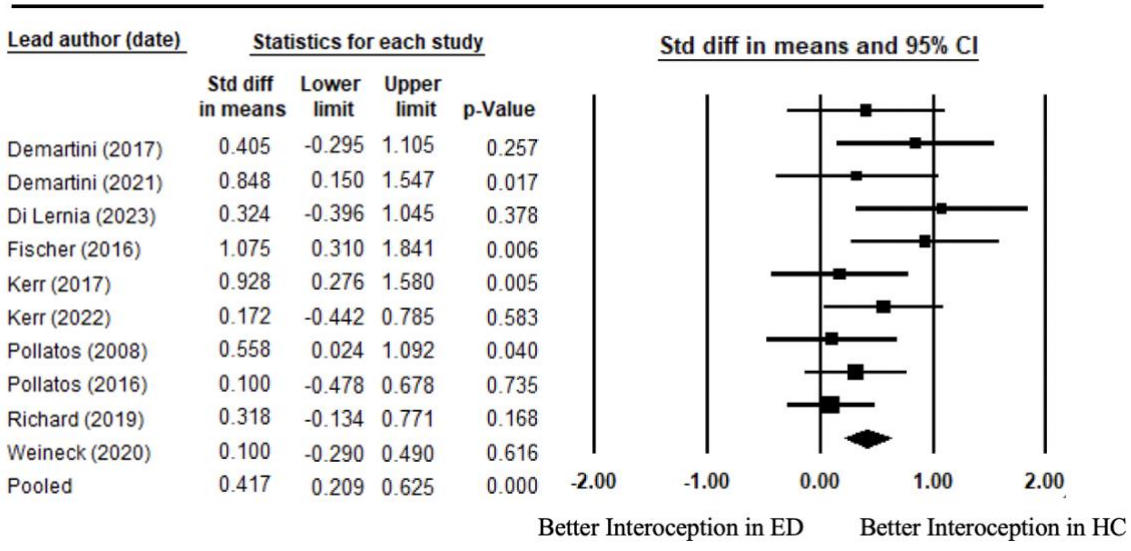
Note: Std diff in means = standardised difference in means (*d*); CI = confidence interval

3.7 Interoceptive Deficits: Interoceptive Modalities

Studies were grouped by interoceptive modality (i.e., sensibility, accuracy, and awareness) to assess the differential impact of each on ED compared to HC samples. IA was unable to be included in analyses given that $N_{samples} = 1$. Individual and pooled effect size data grouped by interoceptive modality are reported in Table 7 and Table 8. A significant and moderate to large effect was observed for the $N = 43$ studies that utilised the EDI, BAQ, and/or BPQ as a measure interoceptive sensibility ($d = 1.818$, 95% CI = 1.593 to 2.044, $p < .001$). The included studies were heterogenous $(Q(42) = 647.58, p < 0.001)$, with $\tau = .83$ and an I^2 value of 93.51% indicating a large amount of variance and dispersion across effect estimates. A significant moderate effect was observed for the $N = 10$ pooled studies that measured interoceptive accuracy using the HCT or visceral sensation ratings ($d = .417$, 95% CI = .209 to .625, $p < .001$). However, between study differences were not statistically significant $(Q(9) = 11.42, p = 0.228)$, with $\tau = .15$ and an I^2 value of 21.51% indicating a small amount of heterogeneity.

Table 6

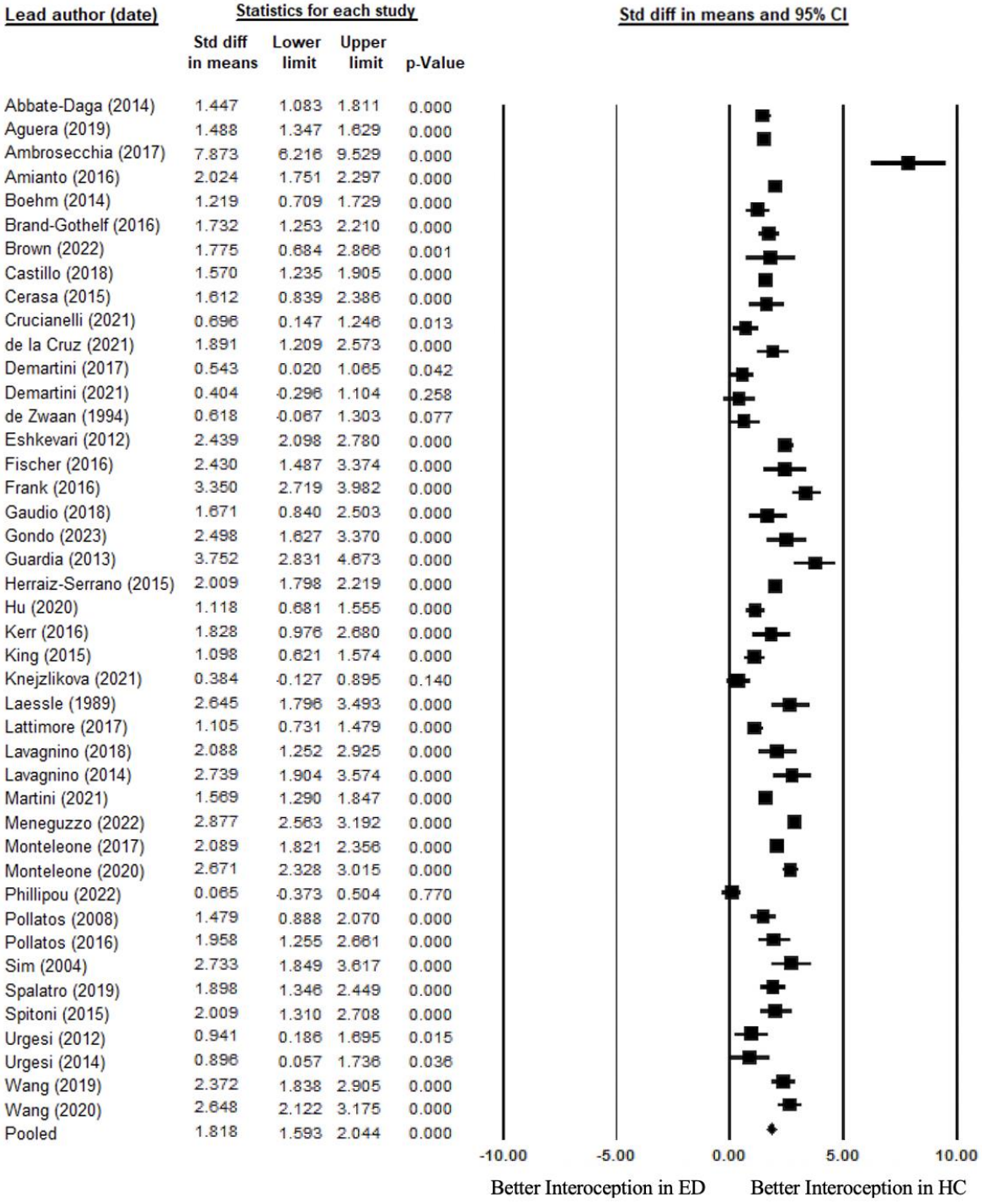
Mean Group Differences in Interoceptive Accuracy (IAcc) with Forest Plot



Note: Std diff in means = standardised difference in means (*d*); CI = confidence interval

Table 7

Mean Group Differences in Interoceptive Sensibility (IS) with Forest Plot



Note: Std diff in means = standardised difference in means (*d*); CI = confidence interval

3.8 Sensitivity Analysis and Meta-Regression

A 'one study removed' sensitivity analysis revealed no statistical outliers. The combined effect across studies decreased from 1.460 to 1.026 and remained significant ($p <$ .001). Meta-regressions were conducted to investigate whether BMI, age, illness onset, and illness duration were significant predictors of effect size. Results from the meta-regressions indicated that none of the proposed moderators were significant predictors of effect size, explaining between .00 to .07 of the variance in each respective model (see Appendix G). Scatterplots for each meta-regression are presented in Appendix H.

4. DISCUSSION

4.1 Overview

The current study synthesised the evidence base on the nature of interoception in EDs, aiming to clarify the degree of interoceptive deficits in EDs and consider potential moderating variables that may influence this relationship. 48 independent studies, comprising a pooled sample of 2,870 ED participants and 2,144 HCs, contributed to pooled effect size data. Results demonstrated a clear presence of interoceptive deficits in ED participants relative to HCs. Within the ED sample, these deficits were greater for individuals with BN than for other ED subgroups, and for interoceptive sensibility (IS) compared to interoceptive accuracy (IAcc). The effects were not moderated by age, BMI, illness onset, nor illness duration. The findings of this study and their limitations are critically reviewed alongside implications for future research and clinical practice.

4.2 Eating Disorders and Interoception

Consistent with previous reviews (Jenkinson et al., 2018; Martin et al., 2019), the present study revealed a significant interoceptive deficit in individuals with EDs. This provides support for the notion that EDs are characterised by a general deficit in sensing, processing, and interpreting bodily signalling arising from the nervous system (Khalsa et al., 2018). Aberrant interoceptive processing within the anterior and dorsal mid-insula has been hypothesised as a basis for understanding how differences in interoceptive ability develops (Kerr et al., 2016). This biological predisposition, in combination with genetic and environmental factors and cognitive frameworks such as reward-learning and habit-learning, have been proposed as core mechanisms that differentiate interoceptive ability (or lack of) in EDs compared to non-clinical populations (Craig, 2009; Khalsa et al., 2022). This theory positions impaired interoception as a factor that shapes the development of ED symptoms, rather than such deficits being a symptom arising from patterns of disordered eating. Yet, what

continues to remain less known is whether impaired interoception necessarily functions as a predisposing factor in EDs. A prospective cohort study found that poorer interoception, as measured by the EDI, predicted ED risk at one-year follow-up (Leon et al., 1995). Similar findings have been replicated more recently (Perkins et al., 2021; Izydorczyk et al., 2021), suggesting that interoceptive deficits may be an important vulnerability factor to consider when identifying at-risk populations. Although conclusions from these studies are limited by their sole use of the EDI to measure interoception, together they emphasise the potential importance of early detection of interoceptive deficits as a preventative measure against disordered eating and EDs.

4.3 Eating Disorder Subtypes and Interoception

The present study also supported the notion of interoceptive deficits functioning as a transdiagnostic process across ED subtypes (Khalsa et al., 2018), with the greatest interoceptive deficit being identified within the pooled BN sample. This finding suggests that greater impairments in top-down cognitive control, as evidenced in BN, may be more influential in shaping interoceptive ability than impaired bottom-up control, as proposed in AN (Herbert & Pollatos, 2018). As interoceptive ability is guided by attunement to internal bodily sensations, and individuals with BN are posited to have poorer gut-to-brain signalling for internal states such as hunger and satiety, it follows that considerable impairment in interoceptive functioning would be present in BN. Conversely, individuals with AN may have hyper-awareness of an inverse brain-to-gut signalling that results in over-control of food intake, thereby overriding natural bottom-up processes. While these processes are impaired and thus contributing to interoceptive deficits in AN, they may be less influential than the under-active top-down signalling that is characteristic of BN. Further research is needed to support this theory, particularly that which integrates measurement of the gut-brain axis into interoceptive assessment.

Additionally, although identified studies that included BED and EDNOS/OSFED samples were limited, preliminary findings indicate that interoceptive deficits may extend across these subtypes also. Such results were highly diverse given substantial within-study variance, though provide some indication on the differential degree of interoceptive impairment across all ED diagnostic subtypes.

4.4. Eating Disorders and Interoceptive Modalities

A further aim of this study was to expand the focus beyond the EDI, a measure predominantly used in the assessment of interoceptive disturbances, to incorporate other subjective and objective measures and explore whether the extent of these deficits differ across interoceptive modalities (i.e., sensibility and accuracy). Findings indicate that interoceptive deficits are present across modalities and are greater when assessed by subjective self-report tools. This finding may be partially explained by the method through which a majority of studies measured IAcc. 80% ($N_{studies}$ = 8) of these studies used a measure of cardiac awareness (i.e., HCT), which has been considered an unreliable assessment of somatic accuracy. 50% ($N_{studies}$ = 4) of these studies were published within the previous four years, suggesting that continued use of the HCT despite identified criticisms remains an unresolved issue in interoceptive research.

Additionally, alternative methods of capturing IAcc may better capture the nature of IAcc impairments in EDs. For instance, the present review included two studies of IAcc that utilised interoceptive sensation ratings that focused on viscera such as the stomach (Kerr et al., 2017, Kerr et al., 2022). These studies confirmed the presence of aberrant gastric functioning in individuals with weight restored AN, suggesting that altered stomach interoception may be a core component influencing restrictive eating behaviours. These findings implicated gastric interoception as perhaps a more meaningful source of information regarding interoception in EDs compared to standard assessment of cardiac recognition.

Indeed, given the nature of EDs has a focus on impaired recognition and/or interpretation of gastric sensations (i.e., hunger, satiety/fullness), this may be a more appropriate method of evaluating IAcc as it better assesses a source of disturbance that is reflected in ED diagnostic criteria. Therefore, pivoting the research focus towards better understanding gastrointestinal functioning in EDs and gastric interoception as an indicator of IAcc may provide a more nuanced perspective on the nature of interoceptive deficits in individuals with EDs.

Another caveat to this finding lies within the limitations of measures on self-reported interoception, for instance the notion that individuals with deficits in awareness are likely to be unreliable in their assessment of such deficits, therefore this may be an inherently flawed method of assessment (Eshkevari et al., 2014). An associated limitation is in considering whether the interoceptive deficits subscale of the EDI is sufficiently capturing interoception, or rather is evaluating one component (i.e., interpretation of internal signalling) whilst not accounting for somatic perception and therefore not measuring interoceptive sensibility as defined by Garfinkel and colleagues (2015). Moreover, items on this subscale appear to reflect emotional, rather than bodily, awareness, therefore may not produce an accurate reflection of interoceptive sensibility, but rather of one's affective experience (Eshkevari et al., 2014; Merwin et al., 2010). As previously noted, other self-report measures such as the MAIA have been suggested as a more suitable method for assessing IS, through its organisation of interoception into eight distinct domains that are designed to comprehensively capture this multifaceted construct (Mehling et al., 2018). Evaluating interoception in this manner may reveal a hierarchy of interoceptive domains as they relate to EDs. Differentiating between these respective domains will be important in refining our understanding of which might meaningfully mediate the relationship between EDs and interoception, thereby allowing for the development of more targeted and thus effective interventions to be administered to individuals with or at risk of developing EDs.

4.5 Meta-regression

It was interesting that none of the potential covariates (i.e., age, BMI, illness onset, and illness duration) made significant contributions to effect size in the present analyses. These non-significant findings may be partially attributed to the meta-regressions collapsing across ED subtypes and interoceptive modalities, thereby distorting unique differences that might exist across these variables. Nonetheless, the findings of the present meta-analyses appear robust irrespective of these covariates, indicating that addressing interoceptive deficits across the spectrum of EDs, regardless of these factors, may be beneficial.

4.6 Limitations and Recommendations

Several methodological limitations should be considered when interpreting results from the present study. First, whilst the breadth of the search strategy and the use of citation alerts were implemented in an effort to capture all relevant studies, the element of subjectivity that was required when determining whether studies met the clinician-diagnosed requirement may have resulted in some studies being unnecessarily excluded. Studies were not considered eligible if there was no explicit mention of the ED sample being diagnosed by a qualified clinician or trained researcher, so it is acknowledged that studies that had such samples, but failed to appropriately report this, would not have been included. Although this is not considered to have impacted on the quality of the results, it may have decreased the sample size from which to draw upon and potentially impacted on the ability to detect significant findings, particularly across the potential moderating variables.

Overall, the quality of the included studies was sound. It is notable, however, that the study by Ambrosecchia et al. (2017) produced an individual effect size that deviated substantially from the other studies. Yet, one-study-removed and funnel plot analyses did not identify this study as significantly impacting the results, potentially resulting from its small sample size, therefore it was retained in the analyses. Next, as identified by Jenkinson and colleagues (2018) and corroborated in the current study, there remains an under-reporting of

clinical data in published studies pertaining to illness onset and illness duration in ED samples. Of the studies included in analyses, 33.3% ($N_{studies}$ = 16) reported on age of ED onset and 62.5% ($N_{studies}$ = 30) reported on ED duration (years). Consequently, in the present study, there was insufficient data available to assess these variables within ED subtypes, which may have contributed to non-significant findings in the meta-regressions. An associated area that was restricted in the breadth of its reporting was on participant gender, with studies only categorising participants as male or female. Whilst gender was not explored in the present study, failure to account for gender diversity in interoceptive research may contribute to imprecision of findings and limited generalisability across gender groups, which may subsequently have implications for the relevance of certain interventions.

Furthermore, there remains a limited number of studies that explore interoception in the context of BED and EDNOS/OSFED, such that the present study was unable to draw meaningful conclusions regarding the extent of interoceptive deficits within these subtypes. It was recognised that stringent eligibility criteria that focused on clinician diagnosed EDs may have narrowed an already restricted sample from which to review. EDNOS/OSFED represents the largest proportion of ED diagnoses, yet it is clear that it is not a focal point of research, potentially due to this category being viewed as a "residual" diagnosis compared to other threshold EDs (Withnell et al., 2022). Such research may extend our understanding of the prediction error and the role of top-down versus bottom-up processing in interoceptive deficits. For instance, BED shares an overlap in symptoms with BD relating to episodes of uncontrolled binge eating, suggesting the presence of atypical brain-to-gut signalling as a potential causal mechanism for BED development.

Similarly, analyses at the level of each interoceptive measure, both objective and subjective, was unable to be conducted based on small sample sizes for each. Given that research has established the presence of interoceptive deficits across measures such as the EDI and HCT, accounting for other interoceptive measures will be an important area for

future review. Newer methods for assessing interoception have more recently emerged, such as body mapping (Khalsa et al., 2018), where participants estimate using a visual body map where they experience specific interoceptive sensations (e.g., heartbeat). This study by Khalsa and colleagues (2018) found that participants with AN experience abnormal representations of their heartbeat both when anticipating and immediately following meal consumption, and that the anxiety associated with this alters the processing of interoceptive signalling. Comparably, Herbert and Pollatos (2018) distinguished and introduced a further facet of interoception identified as Interoceptive Emotional Evaluation (IE), that was found to interact with IAcc and be influential in shaping eating behaviours. IE is captured via subjective assessment ratings of affect associated with interoceptive sensations and perceptions (Herbert & Pollatos., 2018). IE is thought to be relevant for understanding EDs due to negative evaluation of internal signalling being a focal component of ED symptomatology. Therefore, assessment of body mapping and operationalisations of IE may broaden our understanding of the relationship between interoception and EDs, particularly by refining how we capture different interoceptive modalities.

Finally, although evaluating the role of comorbidities was outside the scope of the present study, it would be pertinent for a future review to make considerations for the interactions between interoception and different diagnoses that are known to be frequently present as comorbid to EDs (e.g., Tan et al., 2023; Kerr-Gaffney et al., 2018; Pallister & Waller, 2008). Indeed, there exists a proposed interaction between interoception and depression (e.g., Dunne et al., 2021; Paulus & Stein, 2010), however findings have been inconsistent regarding the strength of the association. Additionally, heightened interoceptive awareness has been thought to be related to the development of anxiety due to overlapping constructs such as body sensitivity and increased emotional arousal (Pollatos et al., 2007). Separating and accounting for the contributing impact of comorbidities on interoceptive ability will help to understand not only perpetuating factors that maintain EDs and strengthen

the interoceptive deficit, but protective factors that may serve to mitigate ED severity or the degree of interoceptive deficit.

Given that the present study has identified a reliable difference in interoception between ED and HC populations, a key clinical implication is that by framing interoception as a skill that can be developed presents a potentially fundamental mechanism for change and intervention target in ED treatment. Specifically, treatment that focuses on enhancing bodily insight may address some of the core maintaining factors in EDs. For instance, if individuals with BN can improve gut-to-brain signalling through interoception-targeted intervention, behaviours that are characteristic of the disorder, such as the loss of control phenomenon, may be reduced. Likewise, assisting individuals with AN to recognise, rather than actively ignore hunger signalling, may counteract disordered behaviours such as restriction and subsequent low weight. Lattimore et al. (2017) identified facets of dispositional mindfulness including present moment awareness and non-judgemental acceptance to be moderately associated with interoceptive deficits and disordered attitudes towards body weight and shape (i.e., drive for thinness) in a clinical ED sample. Furthermore, within a non-clinical at-risk sample, interoceptive deficits were found to mediate the relationship between mindfulness and ED indicators, while non-acceptance of emotional arousal, a component of interoception, was implicated as a specific variable mediating this relationship (Lattimore et al., 2017). However, these findings were not replicated within the clinical sample, potentially attributable to small sample sizes and mixed diagnoses. Nonetheless, it suggests the importance of mindfulness-based-programs (MBPs) that focus on enhancing specific aspects of interoception as a way of targeting eating symptoms (Lattimore et al., 2017). For instance, Vanzhula and Levinson (2020) proposed that a specific interoceptive mechanism that can be targeted by MBPs is increasing awareness of and attention to physical sensations of hunger and fullness. MBP's such as mindful meditation and body scanning have been shown to improve both

interoceptive sensitivity and accuracy in interoceptive judgements in non-clinical populations (Kristeller et al., 2014; Fischer et al., 2017).

Other, more preliminary evidence of such treatment being effective has also been established. A review and meta-analysis on the efficacy of MBPs on reducing ED symptoms found that such intervention was effective in AN, BN, and BED populations (Turgon et al., 2019). Specifically, MBPs were associated with improved BMI (i.e., weight gain) and reductions in restrained eating in AN and BN participants. Results further indicated that MBPs may be effective in reducing emotional eating, negative affect, and body dissatisfaction across EDs (Turgon et al., 2019). Such outcomes were thought to be related to mindfulness being a tool for improving acceptance in body image and enhancing attention and acceptance of sensations of hunger and satiety (i.e., interoception). The authors acknowledged these conclusions as tentative given the limited number of available studies and the lack of control conditions in half of the included studies. Additionally, despite the subtypes being distinct, the review grouped AN and BN samples when evaluating outcomes, therefore conclusions on how improving interoception differentially impacts these subtypes were unable to be drawn. Nonetheless, such findings are promising and suggest that the pathway through which interoceptive interventions can effectively target EDs is through reducing the severity of core symptoms. In this sense, future research should explore whether other putative risk/maintaining factors in EDs, such as compensatory behaviours (e.g., excessive exercise, purging) and abnormal eating patterns (e.g., bingeing) may also be modifiable through interventions such as MBPs, thereby enhancing the overall efficacy of treatment.

4.7 Conclusion

Results from this systematic review and meta-analysis extend upon previous findings of a significant interoceptive deficit in EDs, demonstrating its presence across different ED subtypes and interoceptive modalities. Such findings contribute to our understanding of

interoception as a multidimensional, transdiagnostic process that may be a core intervention target in the treatment of EDs, such as via mindfulness-based-interventions. Despite identified limitations, the present findings have promising implications that are necessary to consider in future research. Specifically, research must address the gaps in our understanding of interoception as it relates to BED and EDNOS/OSFED, comorbidities, and variables including illness duration and illness onset. Additionally, broadening the scope on more reliable and precise measurements of interoception (e.g., MAIA) and ensuring that these measures account for the multifaceted nature of interoception, will help to better differentiate between interoceptive modalities and achieve consensus around definitions of these distinct domains.

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APPENDICES

Appendix A: Instructions to Authors : International Journal of Eating Disorders

DETAILED MANUSCRIPT PREPARATION GUIDANCE

https://onlinelibrary.wiley.com/page/journal/1098108x/homepage/forauthors.html

Title Page

The Title Page of the manuscript should comprise:

- A brief informative title containing the major keywords. The title should not contain abbreviations (see Wiley's best practice SEO tips).
- All co-author details, including affiliation and email address, and ORCID identifier where possible.
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- An author contributions statement that succinctly indicates how each author contributed to the piece of work, using the CRediT "Contributor Roles Taxonomy". Author contributions are also required within the submission form of both original and revised submissions.
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Abstract

The Abstract provides a succinct summary of the article content. The recommended format and word limit vary by article type.

Structured abstracts have a recommended maximum of 250 words and should be organized into: Objective: state the primary purpose of the article, or major question addressed in the study. Method: indicate the sources of data, give brief overview of methodology, or, if it is a review article, how the literature was searched and articles were selected for discussion. For research-based articles, briefly note study design, how participants were selected, and major study measures. If your data are based on a preregistered study, provide the preregistration number or link. Results: summarize the key findings. Discussion: indicate main clinical, theoretical, or research applications/implications.

Main Text File

The main text file should be in MS Word and include the following content and recommended formatting:

- Main body, formatted as Introduction, Method, Results, and Discussion, asrecommended by the International Committee of Medical Journal Editors (ICMJE) (J. Pharmacol. Pharmacother. 2010, 1, 42–58). Exceptions to these formatting recommendations include Commentaries, Forum articles, and Perspective articles.
- A Public Significance statement (< 70 words) that explains why this research is important and is written in plain English for a general, educated public.
- Figure titles should be supplied as a complete list in the text.

References

Please refer to article types regarding the number of permissible references.

This journal offers Free Format submission and authors may submit using their preferred referencing style, as long as consistency is applied throughout the manuscript.

The typesetter will apply the American Psychological Association reference style on manuscripts accepted for publication. If authors wish, they may review reference style guidelines prior to submission.

Tables

Tables should include a descriptive title and, if needed, footnotes defining abbreviations and any other information critical to interpreting the data shown.

Figures

Figures should have legends (and if needed, notes) that succinctly describe the information being displayed. Figures should be uploaded in the highest resolution possible.

Supporting Information

Supporting Information is information that is supplementary and not essential to the article but provides greater depth and background. Examples include more detailed descriptions of therapeutic protocols, results related to exploratory or post-hoc analyses, and elements otherwise not suitable for inclusion in the main article, such as video clips, large sections of tabular data, program code, or large graphical files. It is *not* appropriate to include in the Supporting Information any text that would normally go into a Discussion section; all discussion-related material should be presented in the main article.

Authors should mention the Supporting Information in the text of the main article to provide context for the reader and highlight where and how the supplemental material contributes to the article. View Wiley's FAQs on Supporting Information.

Supporting (supplemental) information should be submitted in separate files.

If accepted for publication, Supporting Information is hosted online together with the article and appears without editing or typesetting.

Note: Authors are encouraged to utilize publicly available data repository for data, scripts, or other artefacts used to generate the analyses presented in the paper; in such cases, authors should include a reference to the location of the material in the Method section (rather than in Supporting Information).

Additional Guidance Regarding Manuscript Preparation

The IJED reaches a global audience. Authors are encouraged to consider the implications of their research for populations, settings, or policies beyond those applicable to their own local circumstances.

For studies involving human participants, to aid comprehensive and consistent reporting across regions/countries and cultures, the IJED provides Demographic Characteristics Reporting Guidelines.

Authors for whom English is not their first language are encouraged to seek assistance from a native or fluent English speaker to proofread the manuscript prior to submission.

Footnotes to the text are not allowed and any such material should be incorporated into the text as parenthetical matter.

Terminology. Authors should refrain from using terms that are stigmatizing, discriminatory, or ambiguous. The journal rejects stand-alone nouns that refer to individuals by their diagnosis or condition (e.g., “anorexics," “obese,” “diabetics," etc.), race and ethnicity identification (e.g., “Whites,” “Hispanics,” etc.), or presumed disadvantaged status (“minorities”). “Participants” should be used in place of “subjects.” For further explanation and examples,

see "*Speaking of that: Terms to avoid or reconsider in the eating disorders field*" (DOI: 10.1002/eat.22528.)

Abbreviations: Only abbreviate terms if they are used repeatedly and the abbreviation is helpful to the reader. Initially, use the word in full, followed by the abbreviation in parentheses. Thereafter, use the abbreviation only.

Units of measurement: Please use the International System of Units. Access www.bipm.fr for more information.

Numbers under 10 should be spelt out, except for: measurements with a unit (8 mmol/L); age (6 weeks old), or lists with other numbers (11 dogs, 9 cats, 4 gerbils).

Trade Names: Chemical substances or drugs should be referred to by the generic name only, not by trade names. For proprietary drugs, the proprietary name and the name and location of the manufacturer should be added in parentheses.

Systematic Reviews, Meta-Analyses and Scoping Reviews

Article Type	**Description**	**Word Limit** Excluding Abstract, References, Tables, Or Figures	**Recommended Abstract Structure/Word Limit**	**Other Requirements/ Recommendations**
Review	Systematic Reviews, Meta-Analyses, and Scoping Reviews	7,500	Structured 250 words	Public Significance Statement

Described below are the reporting requirements for all review paper types. Please be sure to read each section prior to submission, **AS WELL AS THE LAST SECTIONS ENTITLED** "**Required Elements for all IJED Review Papers"** and **"Recommended**

Elements for all IJED Review Papers". These last sections describe elements that are common to IJED systematic reviews, meta-analyses, and scoping reviews.

Systematic Reviews and Meta-Analyses: These articles critically review the status of a given research area and propose new directions for research and/or practice. Both systematic and meta-analytic review papers are welcomed if they review a literature that is advanced and/or developed to the point of warranting a review and synthesis of existing studies. Reviews of topics with a limited number of studies are unlikely to be deemed as substantive enough for this IJED review paper type. The journal does not accept papers that merely describe or compile a list of previous studies without a critical synthesis of the literature that moves the field forward.

All systematic reviews and meta-analyses must follow the **PRISMA Guidelines**, summarized in the Page et al. (2021) article entitled *"The PRISMA 2020 statement: an updated guideline for reporting systematic reviews"* (J. Clin. Epidemiol.). See **translations of PRISMA documents**. Authors who choose this contribution type must include the **2020 PRISMA Flow Diagram** and **complete the PRISMA Checklist upon submission of the manuscript**. During the submission process, authors will be prompted to confirm they have followed the Review checklist in the submission form. The rationale for any unchecked items on the Review Checklist must be explicitly described in the accompanying Cover Letter.

Required Elements for all IJED Review Papers: In addition to the required PRISMA components for systematic reviews, meta-analyses, and scoping reviews described above, all of these review article types must also include the following:

- **Search date:** All IJED review papers must include the month/year that the last literature search was conducted. This date must be within 6 months of the manuscript submission date.
- **Unpublished research:** IJED review papers should aim to include all available literature on the topic, regardless of publication status. Authors should attempt to locate unpublished data by using online databases (e.g., ProQuest, ETHoS, MedRxiv, PsyArXiv, gov) and directly contacting authors if relevant data are not included in published or unpublished works.
- **Sociodemographic characteristics:** A full description of the age, sex assigned at birth and/or gender, race, ethnicity, and socioeconomic status of participants in the reviewed studies must be included in all IJED review papers. Please see the IJED **Demographic Characteristics Reporting Guidelines** for more information definitions of these variables. Please note that reporting this sociodemographic information is required for all IJED review papers (rather than just recommended), as these data are critical for future meta-analyses and for understanding to whom the current literature base applies. In terms of reporting the data, authors should include separate columns/entries for the sociodemographic variables in tables describing the studies included in the review. If a paper included in the review does not report these demographic variables, then "NR" (Not Reported) must be indicated in the appropriate table cells. All review papers must also explicitly discuss in the main manuscript text the diversity of the samples and the ways in which this diversity (or lack thereof) may impact the generalizability and representativeness of the review's results and conclusions.
- **Non-English language articles:** In the interest of representing the global literature, authors are strongly encouraged to include non-English language articles where practically possible. Minimally, authors are expected to initially search the literature without filtering out non-English language articles. In their PRISMA flow diagram, authors should report

the number of articles they excluded based on language. References of articles excluded due to language barriers should be saved in a supplemental file, along with English-language abstracts if available. The supplemental file containing these references and abstracts must be uploaded when submitting the review article. While not required, to the extent possible, we encourage authors to pursue opportunities for accessing non-English language papers such as inviting collaborators with the requisite language skills; employing translation software; or seeking expert assistance in translating articles.

Appendix B: Logic Grids

Table B1

Logic Grid for PsycINFO

Eating Disorder	AND	Interoception
Exp eating disorders OR Appetite disorder*.ti,ab OR Disordered eating.ti,ab OR Anorexia.ti,ab OR Bulimia.ti,ab OR eating pathology.ti,ab OR pathologic* eating.ti,ab		Interoception.sh OR Interocepti*.ti,ab OR Physiological proces*.ti,ab OR Som?esthetic percepti*.ti,ab OR Sensorimotor.ti,ab OR viscerocept*.ti,ab OR Psychophysiol*.ti,ab OR Physiological state.ti,ab OR Internal state.ti,ab OR Internal signal*.ti,ab OR Body aware*.ti,ab OR Body perception.ti,ab OR Somatosensory perception.ti,ab

Note: Search conducted on February 5, 2023. Search yielded 648 results.

Table B2

Logic Grid for Embase

Eating Disorder	AND	Interoception
Exp eating disorder OR Appetite disorder*.ti,ab OR Anorexia.ti,ab OR Bulimia.ti,ab OR Disordered eating.ti,ab OR Eating pathology.ti,ab OR Pathologic* eating.ti,ab		Interoception.sh OR Interocepti*.ti,ab OR Physiological proces*.ti,ab OR Som?esthetic percepti*.ti,ab OR Sensorimotor.ti,ab OR viscerocept*.ti,ab OR Psychophysiol*.ti,ab OR Physiological state.ti,ab OR Internal state.ti,ab OR Internal signal*.ti,ab OR Body aware*.ti,ab OR body trust*.ti,ab OR Body perception.ti,ab OR Somatosensory perception.ti,ab

Note: Search conducted on February 5, 2023. Search yielded 948 results.

Table B3

Logic Grid for Emcare

Eating Disorder	AND	Interoception
Exp eating disorder OR Appetite disorder*.ti,ab OR Anorexia.ti,ab OR Bulimia.ti,ab OR Disordered eating.ti,ab OR Eating pathology.ti,ab OR Pathologic* eating.ti,ab		Interoception.sh OR interocepti*.ti,ab OR physiological proces*.ti,ab OR som?esthetic percepti*.ti,ab OR Sensorimotor.ti,ab OR viscerocept*.ti,ab OR Psychophysiol*.ti,ab OR Physiological state.ti,ab OR Internal state.ti,ab OR Internal signal*.ti,ab OR Body aware*.ti,ab OR body trust*.ti,ab OR Body percept*.ti,ab OR Somatosensory perception.ti,ab

Note: Search conducted on February 5, 2023. Search yielded 337 results.

Table B4

Logic Grid for CINAHL

Eating Disorder	AND	Interoception
MH “eating disorders+” OR TI (anorexia OR bulimia OR disordered eating OR eating pathology OR pathologic* eating) OR AB (anorexia OR bulimia OR disordered eating OR eating pathology OR pathologic* eating)		TI (interocept* OR “body aware*” OR “physiological proces*” OR “som#esthetic percepti*” OR viscerocept* OR psychophysiol* OR “physiological state” OR “internal state” OR “internal signal*” OR “body aware*” OR “body percept*” OR “somatosensory perception”) OR AB (interocept* OR “body aware*” OR “physiological proces*” OR “som#esthetic percepti*” OR viscerocept* OR psychophysiol* OR “physiological state” OR “internal state” OR “internal signal*” OR “body aware*” OR “body percept*” OR “somatosensory perception”)

Note: Search conducted on February 5, 2023. Search yielded 188 results.

Table B5

Logic Grid for Web of Science

Eating Disorder	AND	Interoception
TS=(”eating disorder*” OR ”disordered eating” OR “appetite disorder*” OR “eating pathology” OR “pathologic* eating” OR anorexia OR bulimia)		TS=(interocept* OR “physiological proces*” OR “som$esthetic percepti*” OR “somatic awareness” OR “somatic perception” OR somato* OR sensorimotor OR viscerocept* OR psychophysiol* OR “physiological state” OR “internal state” OR “internal signal*” OR “body aware*” OR “body perception” OR “somatosensory perception”)

Note: Search conducted on February 5, 2023. Search yielded 1,514 results.

Table B6

Logic Grid for PubMed

Eating Disorder	AND	Interoception
“feeding and eating disorders”[mh] OR eating disorder*[tiab] OR appetite disorder*[tiab] OR disordered eating[tiab] OR anorexia[tiab] OR bulimia[tiab] OR eating pathology [tiab] OR pathologic eating [tiab] OR pathological eating [tiab]		“Interoception”[mh] OR interocepti*[tiab] OR physiological proces*[tiab] OR somesthetic percepti*[tiab] OR Sensorimotor*[tiab] OR viscerocept*[tiab] OR Psychophysiol*[tiab] OR Physiological state[tiab] OR Internal state[tiab] OR Internal signal[tiab] OR Body aware*[tiab] OR Body percept*[tiab] OR Somatosensory perception[tiab]

Note: Search conducted on February 19, 2023. Search yielded 708 results.

Appendix C: PRISMA Checklist

Table C1

Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Checklist (Page et al., 2020). This checklist is adapted for International Journal of Eating Disorders (IJED) from: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

Section and Topic	Item #	Checklist item	Reported on page
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both. The Title includes one or two keywords to optimize search engine discoverability of the article.	I
ABSTRACT			
Abstract	2a	See the PRISMA 2020 for Abstracts checklist. The Abstract is structured and is a recommended maximum of 250 words. Using the headers "Objective," "Method," "Results," and "Discussion," the Abstract concisely summarizes the article. The Abstract includes at least three of the manuscript's identified keywords.	IX
Keywords	2b	Keywords are provided that capture relevant core concepts. Keywords may be single words ("health") or short multi-word terms ("health services utilization"). The Editor recommends at least five keywords.	X
Public Significance	2c	The Public Significance statement (< 70 words) explains why this research is important. It is written in plain English for a general, educated public.	IX
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	1-6
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the paper addresses.	6-7
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	8-9
Information sources	6	Include a search of the unpublished ("grey") literature (e.g., search Proquest, Google Scholar, Scopus, etc.). Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted. The search date must be within 6 months of the submission date.	8

Section and Topic	Item #	Checklist item	Reported on page
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used. Do not limit the initial search to the English-only literature. If you must ultimately exclude non-English language articles (e.g., due to inability to retrieve full texts, language barriers, etc.), create a reference list of all non-English language articles you excluded and upload the reference list in a supplemental file with your submission.	59-61
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	9
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	9
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	9
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	9
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	11
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	10-11
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	10-11
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	9-10
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	9-11
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	10-11

Section and Topic	Item #	Checklist item	Reported on page
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	11
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	12
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	11-12
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	10
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	15
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	15
Study characteristics	17	Cite each included study and present its characteristics.	70-74
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	68-69
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g., confidence/credible interval), ideally using structured tables or plots.	19, 21-24
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	18, 20, 21, 23
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g., confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	18, 20, 21, 23
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	18
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	25
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	18
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	18-24

Section and Topic	Item #	Checklist item	Reported on page
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	26-30
	23b	Discuss any limitations of the evidence included in the review.	30-33
	23c	Discuss any limitations of the review processes used.	30
	23d	Discuss implications of the results for practice, policy, and future research.	30-35
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	8
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	8
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	VIII
Competing interests	26	Declare any competing interests of review authors.	VIII
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: Template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	VIII

Appendix D: Standard Quality Assessment Criteria for Evaluating Primary Research Papers from a Variety of Fields

Table D1

QualSyst Checklist for assessing the quality of quantitative studies (summarised from Kmet et al., 2004)

Criterion	**Yes (score 2)**	**Partial (score 1)**	**No (score 0)**
Question / objective sufficiently described?	Aims and/or research question(s) clearly identifiable in the introductory section (or first paragraph of methods section).	Vaguely/incompletely reported *or* information needs to be gathered from parts of the paper other than the introduction/background/objectives.	Question or objective not reported or is incomprehensible.
Study design evident and appropriate?	Design easily identified and appropriate to address the study question/objective.	Design and/or study question not clearly identified, but appears appropriate	Design used does not answer study question *or* design cannot be identified.
Method of subject/comparison group selection or source of information/input variables described and appropriate?	Described and appropriate. Selection strategy designed to obtain unbiased sample. Methods and setting of recruitment reported for studies including volunteers.	Selection methods incompletely described but appears appropriate *or* selection strategy may have introduced bias but unlikely to have seriously distorted results.	No information provided *or* clearly inappropriate selection procedures.
Subject (and comparison group, if applicable) characteristics sufficiently described?	Sufficient relevant baseline/demographic information. If "healthy volunteers" are used, age and sex must be reported (at minimum).	Poorly defined criteria *or* incomplete relevant baseline/demographic information (e.g., likely confounding variables not reported).	No baseline/demographic information provided.
Outcome and (if applicable) exposure measure(s) well defined and robust to	Defined and measured according to "objective" criteria (e.g., clinical scores). Little or minimal potential	Definitions lack detail or leave room for subjectivity *or* instrument/mode of assessment(s) not reported.	Measures undefined or are inconsistent throughout paper *or* misclassification errors/measurement

measurement/misclassification bias? Means of assessment reported?	for measurement/misclassification errors.		bias likely to have seriously distorted the results
Sample size appropriate?	Appears reasonable with respect to the outcome under study and study design. Appropriate sample size can be assumed when statistically significant results are achieved for major outcomes.	Insufficient data to assess sample size (e.g., no mention of power/effect size/variance estimates).	Clearly inadequate (e.g., statistically non-significant results).
Analytic methods described/justified and appropriate?	Analytic methods described (e.g., "chi square"/"t-tests") and appropriate	Analytic methods not reported but are likely appropriate.	Analytic methods not described and cannot be determined *or* obviously inappropriate.
Some estimate of variance is reported for the main results?	Appropriate variance estimate(s) provided (e.g., range, distribution, confidence intervals).	Undefined "+/-" expressions *or* no specific data given but insufficient power acknowledged as a problem.	No information regarding uncertainty of the estimates.
Controlled for confounding?	Randomised study with comparability of baseline characteristics reported *or* appropriate control of confounds at design or analysis stage.	Incomplete control of confounding *or* confounding not considered but unlikely to have seriously distorted the results.	Confounding not considered and may have seriously distorted the results.
).Results reported in sufficient detail?	Results include major outcomes and all secondary outcomes	Quantitative results reported for only some outcomes.	Results reported for a subsample only *or* results for some outcomes are only qualitatively reported when quantitative reporting would have been possible.
.Conclusions supported by the results?	All conclusions supported by the data. Authors address all results (e.g., do not just focus on significant findings)	Some major conclusions supported by the data, some are not	None or small portion of major conclusions are supported by data *or* conclusions are missing.

Appendix E: Risk of Bias Assessment

Table E1

Reporting quality of included studies based on QualSyst ($N_{studies}$ = 48)

Lead Author (date)	1	2	3	4	5	6	7	8	9	10	11	Total Sum	Total Sum ÷ Total Possible Score
Abbate-Daga (2014)	2	2	2	2	1	2	2	2	2	2	2	21	.95
Aguera (2019)	2	2	1	2	1	1	2	2	2	2	2	19	.86
Ambrosecchia (2017)	2	2	1	2	1	2	2	2	2	2	2	20	.91
Amianto (2016)	2	2	2	2	1	2	2	2	2	2	2	21	.95
Boehm (2014)	2	2	1	2	2	2	2	2	2	2	2	21	.95
Brand-Gothelf (2016)	2	2	1	2	1	1	2	2	2	2	2	19	.86
Brown (2022)	2	2	1	2	2	1	2	2	2	2	2	20	.91
Castillo (2018)	2	2	1	2	1	2	2	2	1	2	2	19	.86
Cerasa (2015)	2	2	1	2	1	1	2	2	2	2	2	19	.86
Crucianelli (2021)	2	2	1	2	2	1	2	2	1	2	2	19	.86
de la Cruz (2021)	2	2	1	2	1	1	2	2	1	2	2	18	.82
de Zwaan (1994)	2	2	1	2	2	1	2	2	2	2	2	20	.91
Demartini (2017)	2	2	1	2	2	1	2	2	1	2	2	19	.86
Demartini (2021)	2	2	1	2	1	2	2	2	1	2	2	19	.86
Di Lernia (2023)	2	2	1	2	2	1	2	2	2	2	2	20	.91
Eshkevari (2012)	2	2	1	2	2	1	2	2	2	2	2	20	.91
Fischer (2016)	2	2	1	2	2	1	2	2	2	2	2	20	.91
Frank (2016)	2	2	1	2	1	2	2	2	2	2	2	20	.91
Gaudio (2018)	2	2	1	2	1	1	2	1	2	2	2	18	.82
Gondo (2023)	2	2	1	2	1	1	2	1	2	2	2	18	.82
Guardia (2013)	2	2	1	2	2	1	2	2	1	2	2	19	.86
Herraiz-Serrano (2015)	2	2	2	2	1	2	2	2	2	2	2	21	.95
Hu (2020)	2	2	1	2	2	1	2	2	1	2	2	19	.86
Kerr (2016)	2	2	1	2	2	2	2	2	1	2	2	20	.91
Kerr (2017)	2	2	1	2	2	2	2	2	2	2	2	21	.95
Kerr (2022)	2	2	2	2	2	1	2	2	2	2	2	21	.95
King (2015)	2	2	2	2	1	2	2	2	2	2	2	21	.95

Lead Author (date)	1	2	3	4	5	6	7	8	9	10	11	Total Sum	Total Sum ÷ Total Possible Score
Knejzlikova (2021)	2	2	2	2	2	1	2	2	2	2	2	21	.95
Laessle (1989)	2	2	1	2	1	2	2	1	1	2	2	18	.82
Lattimore (2017)	2	2	1	2	2	1	2	2	1	2	2	19	.86
Lavagnino (2014)	2	2	1	2	1	1	2	2	2	2	2	19	.86
Lavagnino (2018)	2	2	1	2	1	2	2	2	2	2	2	20	.91
Martini (2021)	2	2	2	2	1	2	2	2	2	2	2	21	.95
Meneguzzo (2022)	2	2	1	2	1	2	2	2	2	2	2	20	.91
Monteleone (2017)	2	2	2	2	1	2	2	2	2	2	2	21	.95
Monteleone (2020)	2	2	2	2	1	2	2	2	1	2	2	20	.91
Phillipou (2022)	2	2	1	2	1	1	2	2	1	2	2	18	.82
Pollatos (2008)	2	2	1	2	1	1	2	2	2	2	2	19	.86
Pollatos (2016)	2	2	1	2	1	2	2	2	2	2	2	20	.91
Richard (2019)	2	2	1	2	2	1	2	2	2	2	2	20	.91
Sim (2004)	2	2	1	2	2	1	2	2	1	2	2	19	.86
Spalatro (2019)	2	2	1	2	1	1	2	2	2	2	2	19	.86
Spitoni (2015)	2	2	1	2	1	1	2	2	2	2	2	19	.86
Urgesi (2012)	2	2	2	2	1	1	2	2	1	2	2	19	.86
Urgesi (2014)	2	2	2	2	1	1	2	2	1	2	2	19	.86
Wang (2019)	2	2	1	2	1	2	2	2	2	2	2	20	.91
Wang (2020)	2	2	2	2	1	2	2	2	2	2	2	21	.95
Weineck (2020)	2	2	2	2	2	1	2	2	1	2	2	20	.91

Scoring note: 2 = criterion met; 1 = criterion partially met

Appendix F: Data Extraction

Table F1

Study And Participant Characteristics Per Included Study

Lead Author (date)	Country	Study Design	*N* (HC)	*N* (Clinical)	ED Diagnoses	ED BMI (*M* ± *SD)*	HC BMI (*M* ± *SD)*	ED Illness Duration (years) (*M* ± *SD)*	ED Illness Onset (Age) (*M* ± *SD)*	Gender (%F)	ED Age (years) (*M* ± *SD)*	HC Age (years) (*M* ± *SD)*	Outcome Measure
Abbate-Dage (2014)	Italy	Cross-sectional	59	94	AN	15.17 ± 1.98	19 ± 2.01	7.13 ± 6.55	-	-	24.74 ± 7.25	25.08 ± 3.23	EDI-2
Aguera (2019)	Spain	Cross-sectional	364	718	Mixed (AN, BN, BED, OSFED)	-	-	-	-	87.06%	31.65 ± 8.23	21.18 ± 4.34	EDI-2
Ambrosecchia (2017)	Italy	Cross-sectional	25	24	AN	16.1 ± 1.47	20.2 ± 3.00	6.0 ± 1.0	16 ± 2.94	100%	23.0 ± 9.0	23 ± 5.5	EDI-3
Amianto (2016)	Italy	Cross-sectional	80	153	AN, BN	AN 15.75 ± 1.62, BN 21.96 ± 2.47	20.2 ± 2.46	-	-	100%	AN 24.56 ± 8.32 BN 28.19 ± 8.80	23.28 ± 0.63	EDI-2
Boehm (2014)	Germany	Cross-sectional	35	35	AN	14.78 ± 1.26	20.3 ± 2.72	1.58 ± 2.25	13.50 ± 1.70	100%	16.10 ± 2.56	16.16 ± 2.64	EDI-2
Brand-Gothelf (2016)	Israel	Cross-sectional	27	40	AN, BN	AN 15.7 ± 1.6 BN 20.8 ± 2.8	20.4 ± 2.80	AN 2.2 ± 1.1 BN 2.6 ± 3.2	AN 13.1 ± 2.3 BN 14.1 ± 5.6	100%	AN 17.8 ± 5.0 BN 22.0 ± 4.7	18.5 ± 4.7	EDI-2
Brown (2022)	USA	Cross-sectional	10	10	AN	17.31 ± 0.80	20.4 ± 2.32	-	-	100%	19.90 ± 2.28	21.70 ± 3.16	MAIA
Castillo (2018)	Spain	Cross-sectional	30	90	AN, BN, UFED	-	-	-	-	90%	AN 17.4 ± 5.27 BN 19.5 ± 5.12 UED 15.9 ± 2.23	17.3 ± 4.21	EDI-2

Lead Author (date)	Country	Study Design	*N* (HC)	*N* (Clinical)	ED Diagnoses	ED BMI (*M* ± *SD*)	HC BMI (*M* ± *SD*)	ED Illness Duration (years) (*M* ± *SD*)	ED Illness Onset (Age) (*M* ± *SD*)	Gender (%F)	ED Age (years) (*M* ± *SD*)	HC Age (years) (*M* ± *SD*)	Outcome Measure
Cerasa (2015)	Italy	Cross-sectional	17	17	Mixed (AN, BN)	23.6 ± 8.2	20.5 ± 4.80	1.33 ± 0.42	-	100%	30.2 ± 5.6	30.1 ± 5.5	EDI-2
Crucianelli (2021)	Italy	Cross-sectional	27	27	AN	14.89 ± 3.41	20.6 ± 3.04	10.92 ± 10.23	17.23 ± 4.45	100%	28.40 ± 10.44	24.48 ± 4.61	EDI and BAQ
de Zwaan (1994)	USA	Cross-sectional	22	43	BED	36.1 ± 3.7	20.64 ± 3.40	-	-	100%	38.8 ± 7.6	40.0 ± 8.7	EDI-2
De La Cruz (2021)	Germany	Cross-sectional	26	22	AN	15.1 ± 1.4	20.64 ± 3.20	-	-	89.58%	23.8 ± 7.2	25.2 ± 6.6	EDI-2
Demartini (2017)	Italy	Cross-sectional	16	16	AN	15.60 ± 2.03	20.67 ± 2.05	-	17.80 ± 5.41	80%	31.10 ± 13.11	42.10 ± 13.34	BAQ and HCT
Demartini (2021)	Italy	Cross-sectional	20	15	AN	16.11 ± 4.33	20.74 ± 3.12	3.5 ± 1.3	-	100%	28.00 ± 11.22	28.59 ± 9.85	EDI-2, BAQ, HCT
DiLernia (2023)	Italy	Cross-sectional	15	15	AN	15.13 ± 1.52	20.8 ± 2.18	-	-	100%	18.93 ± 3.97	22 ± 0.59	HCT
Eshkevari (2012)	UK	Cross-sectional	61	78	AN, BN, EDNOS	AN 16.1 ± 2.71 BN 20.9 ± 4.28 EDNOS 19.7 ± 5.54	20.8 ± 2.80	AN 6.0 ± 11 BN 7.0 ± 4.0 EDNOS 11.5 ± 12	-	100%	AN 23.0 ± 18 BN 22.5 ± 10 EDNOS 27.5 ± 16	24.0 ± 7	EDI-3
Fischer (2016)	Germany	Cross-sectional	15	15	AN	15.7 ± 1.3	20.81 ± 1.80	-	-	100%	27.4 ± 7.8	27.9 ± 7.6	EDI-2, HCT
Frank (2016)	USA	Cross-sectional	27	41	AN, BN	AN 16.0 ± 1.1 BN 22.6 ± 5.7	20.83 ± 1.40	-	-	100%	AN 23.10 ± 6.14 BN 25.15 ± 5.31	26.15 ± 6.95	EDI-3
Gaudio (2018)	Italy	Cross-sectional	15	15	AN	16.1 ± 1.2	21 ± 2.40	0.33 ± 0.15	15.2 ± 1.6	100%	15.7 ± 1.7	16.1 ± 1.4	EDI-2

Lead Author (date)	**Country**	**Study Design**	***N* (HC)**	***N* (Clinical)**	**ED Diagnoses**	**ED BMI (*M* ± *SD*)**	**HC BMI (*M* ± *SD*)**	**ED Illness Duration (years) (*M* ± *SD*)**	**ED Illness Onset (Age) (*M* ± *SD*)**	**Gender (%F)**	**ED Age (years) (*M* ± *SD*)**	**HC Age (years) (*M* ± *SD*)**	**Outcome Measure**
Gondo (2023)	Japan	Longitudinal	18	18	AN	13.4 ± 1.7	21 ± 1.80	9.17 ± 9.08	-	100%	28.5 ± 9.9	28.4 ± 7.5	EDI
Guardia (2013)	France	Cross-sectional	25	25	AN	14.90 ± 1.11)	21 ± 1.73	4.57 ± 6.52	-	100%	22.24 ± 8.60	22.88 ± 3.63	EDI-2
Herraiz-Serrano (2015)	Spain	Cross-sectional	127	196	AN, BN, EDNOS	-	-	-	-	-	23.2 ± 5.89	-	EDI
Hu (2020)	China	Cross-sectional	47	46	AN	15.0 ± 2.0	21.1 ± 1.70	1.24 ± 1.29	15.8 ± 4.2	100%	17.6 ± 5.5	18.7 ± 2.2	EDI-2
Kerr (2016)	USA	Cross-sectional	15	15	AN	19.8	21.23 ± 1.00	1.67 ± 1.95	-	100%	17	18	EDI-3
Kerr (2017)	USA	Cross-sectional	20	20	AN	19.84 ± 0.87	21.3 ± 1.55	-	-	100%	17 ± 3	18 ± 3	Interoceptive sensation ratings
Kerr (2022)	USA	Longitudinal	21	22	AN	16.17 ± 1.36	21.3 ± 1.98	-	-	100%	18.35 ± 5.09	17.62 ± 3.71	WLT
King (2015)	Germany	Cross-sectional	40	40	AN	14.8 ± 1.3	21.39 ± 2.70	1.5 ± 2.17	14.4 ± 1.9	100%	15.9 ± 2.5	16.2 ± 2.9	EDI-2
Knejzlikova (2021)	Czechia	Cross-sectional	30	30	AN	16.9 ± 3.73	21.42 ± 2.60	-	-	100%	14.9 ± 1.31	15.7 ± 1.09	BPQ: Awareness and ANS Subscales
Laessle (1989)	Germany	Cross-sectional	20	20	BN	20.3 ± 2.2	21.49 ± 1.90	5.8 ± 2.7	-	100%	23.5 ± 4.0	23.7 ± 2.2	EDI-2
Lattimore (2017)	UK	Cross-sectional	137	39	Mixed (AN, BN, BED, EDNOS)	-	-	-	-	100%	29 ± 1.5	21 ± 0.5	EDI-2

Lead Author (date)	Country	Study Design	*N* (HC)	*N* (Clinical)	ED Diagnoses	ED BMI (*M* ± *SD*)	HC BMI (*M* ± *SD*)	ED Illness Duration (years) (*M* ± *SD*)	ED Illness Onset (Age) (*M* ± *SD*)	Gender (%F)	ED Age (years) (*M* ± *SD*)	HC Age (years) (*M* ± *SD*)	Outcome Measure
Lavagnino (2014)	Italy	Cross-sectional	18	16	BN	22 ± 2	21.5 ± 2.00	1.42 ± 1	-	100%	23 ± 5	23 ± 3	EDI-2
Lavagnino (2018)	Italy	Cross-sectional	24	19	AN	AN 16.0 ± 1.1	21.5 ± 1.30	-	-	100%	23.1 ± 5.8	27.4 ± 6.3	EDI-2
Martini (2021)	Italy	Cross-sectional	121	139	AN	14.64 ± 2.23	21.5 ± 2.45	5.20 ± 6.06	-	93.46%	22.89 ± 6.98	25.61 ± 4.05	EDI-2, MAIA
Meneguzzo (2022)	Italy	Cross-sectional	43	172	AN, BN, BED	AN 15.51 ± 6.53 BN 22.69 ± 6.72 BED 35.76 ± 5.96	21.6 ± 2.74	-	-	100%	AN 25.15 ± 7.13 BN 25.37 ± 8.74 BED 29.79 ± 11.22	24.60 ± 5.65	EDI-3
Monteleone (2017)	Italy	Cross-sectional	117	123	AN, BN	AN 16.7 ± 3.6 BN 24.1 ± 8.9	21.6 ± 1.90	-	-	100%	AN 24.7 ± 7.8 BN 27.8 ± 9.4	24.7 ± 3.1	EDI-2
Monteleone (2020)	Italy	Cross-sectional	77	100	AN, Mixed (AN-P, BN)	AN-R 16.74 ± 2.08 BN 21.59 ± 6.07	21.65 ± 2.06	AN 7.21 ± 6.87 Mixed 9.25 ± 8.33	AN 18.16 ± 5.72 Mixed 19.98 ± 7.15	100%	AN 25.45 ± 8.02 Mixed 27.14 ± 9.78	25.58 ± 2.31	EDI-2
Phillipou (2022)	Australia	Cross-sectional	20	20	AN	19.16 ± 3.04	21.68 ± 3.20	5.05 ± 3.17	9.97 ± 6.04	100%	22.50 ± 2.59	24.05 ± 4.39	MAIA
Pollatos (2016)	Germany	Cross-sectional	23	23	BN	20.9 ± 3.4	21.74 ± 2.50	5.9 ± 3.7	17.0 ± 3.1	100%	24.0 ± 7.2	25.1 ± 3.2	EDI, HCT
Pollatos (2008)	Germany	Cross-sectional	28	28	AN	16.59 ± 1.16	21.8 ± 4.28	2.5 ± 3.2	-	100%	21.43 ± 2.38	22.39 ± 4.78	EDI, HCT
Richard (2019)	Germany	Cross-sectional	39	37	AN	15.4 (1.80)	21.95 ± 1.76	-	-	100%	22.5 ± 5.06	22.0 ± 3.55	HCT
Sim (2004)	USA	Cross-sectional	19	19	Mixed (BN, EDNOS)	-	-	-	-	100%	16.67 ± 1.5	16.67 ± 1.33	EDI

Lead Author (date)	Country	Study Design	*N* (HC)	*N* (Clinical)	ED Diagnoses	ED BMI (*M* ± *SD*)	HC BMI (*M* ± *SD*)	ED Illness Duration (years) (*M* ± *SD*)	ED Illness Onset (Age) (*M* ± *SD*)	Gender (%F)	ED Age (years) (*M* ± *SD*)	HC Age (years) (*M* ± *SD*)	Outcome Measure
Spaltro (2019)	Italy	Cross-sectional	17	41	AN, BN	AN 15.99 ± 0.92 BN 21.84 ± 2.35	22 ± 1.85	-	-	100%	AN 20.33 ± 4.42 BN 21.56 ± 2.35	23.27 ± 2.19	EDI-2
Spitoni (2015)	Italy	Cross-sectional	32	18	AN	16 ± 1.3	22.1 ± 2.40	3.89 ± 1.51	-	100%	24.8 ± 3.71	23.9 ± 4.24	EDI-2
Urgesi (2012)	Italy	Cross-sectional	15	15	Mixed (AN, EDNOS)	17 (1.1)	23.38 ± 2.00	1.54 ± 1.83	14 ± 1.3	100%	15.5 (1.2)	15.4 ± 1.2	EDI-2
Urgesi (2014)	Italy	Cross-sectional	12	12	Mixed (AN, EDNOS)	17 (1.8)	23.6 ± 1.90	1.95 ± 1.25	16.1 ± 5.6	100%	20.8 ± 7.7	19.83 ± 7.64	EDI-3
Wang (2019)	China	Cross-sectional	44	48	BN	21.0 ± 2.6	24 ± 1.40	2.0 ± 1.3	-	100%	22.0 ± 3.4	23.1 ± 3.4	EDI
Wang (2020)	China	Cross-sectional	53	51	BN	20.8 ± 2.2	24.1 ± 1.70	1.9 ± 1.3	-	100%	-	-	EDI
Weineck (2020)	Germany	Cross-sectional	51	50	Mixed (AN, Atypical AN)	15.51 ± 2.13	34.3 ± 2.21	7.78 ± 6.75	-	100%	23.88 ± 6.33	22.25 ± 3.49	HCT

Note: HC = healthy control; ED = eating disorder; BMI = body mass index; AN = anorexia nervosa; BN = bulimia nervosa; BED = binge eating disorder; EDNOS = eating disorder not otherwise specified; OSFED = other specified feeding and eating disorder; UFED = unspecified feeding and eating disorder; *M* = mean; *SD* = standard deviation.

Appendix G: Meta-Regression Summary

Table G1

Summary of Meta-Regressions for each Moderator Variable

Moderator Variable	$N_{studies}$	*Q*	*P*
Age	36	0.02	.883
BMI	33	0.13	.723
Illness Duration	21	0.34	.561
Illness Onset	10	0.73	.393

Note: $N_{studies}$ = number of studies providing these data; *Q* = Q-statistic; *P* = *p*-value.

Appendix H: Meta-Regression Scatterplots

Figure H1

Regression of Standardised Difference in Means on Age

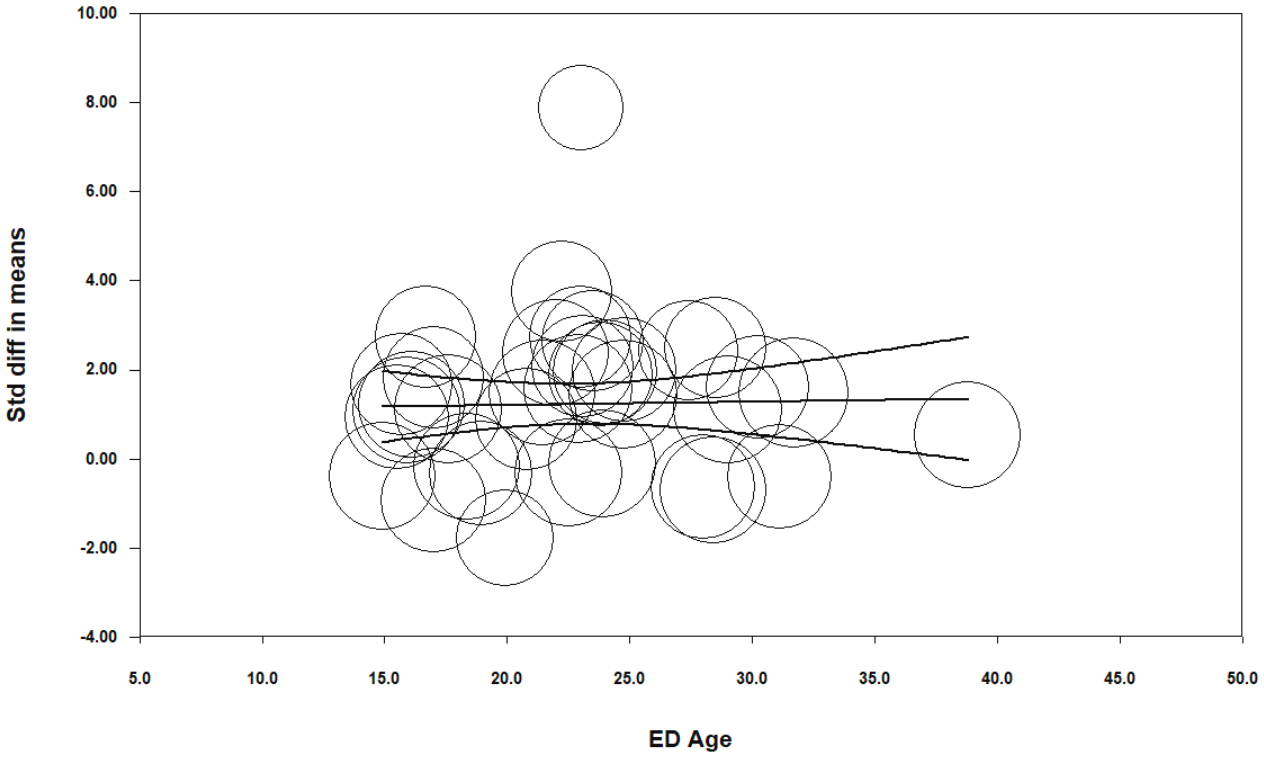

Figure H2

Regression of Standardised Difference in Means on BMI

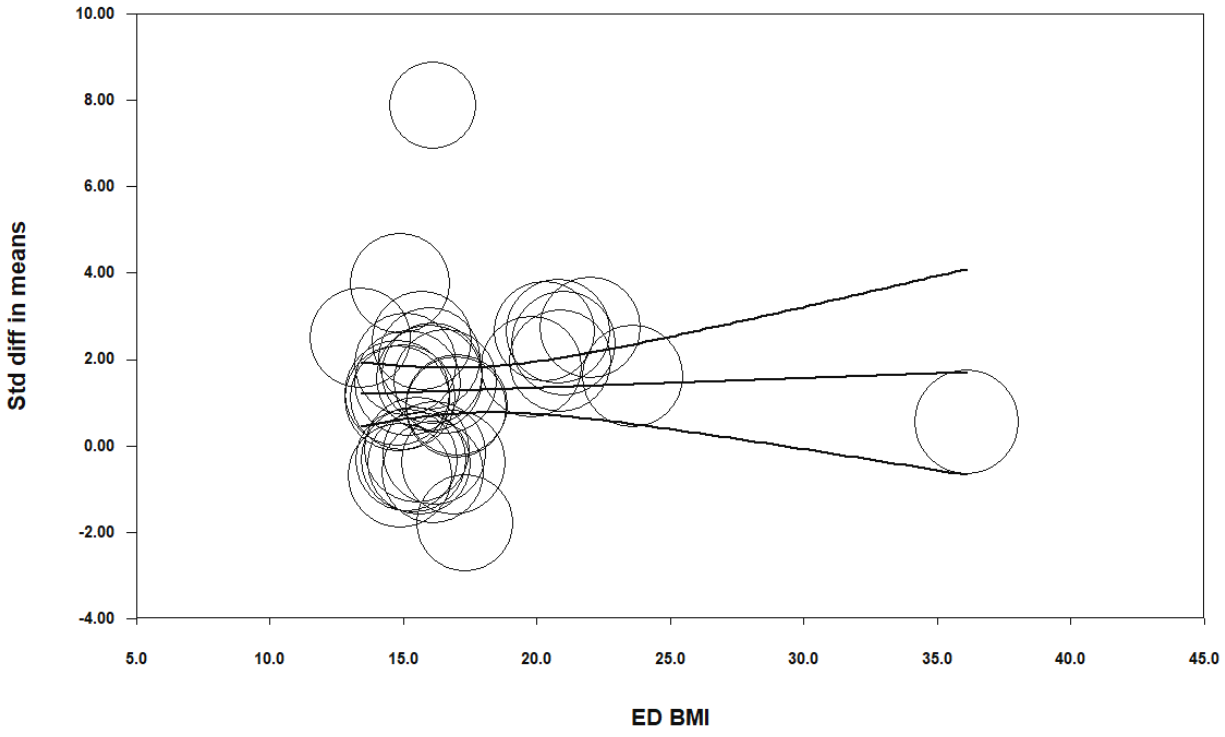

Figure H3

Regression of Standardised Difference in Means on Illness Onset

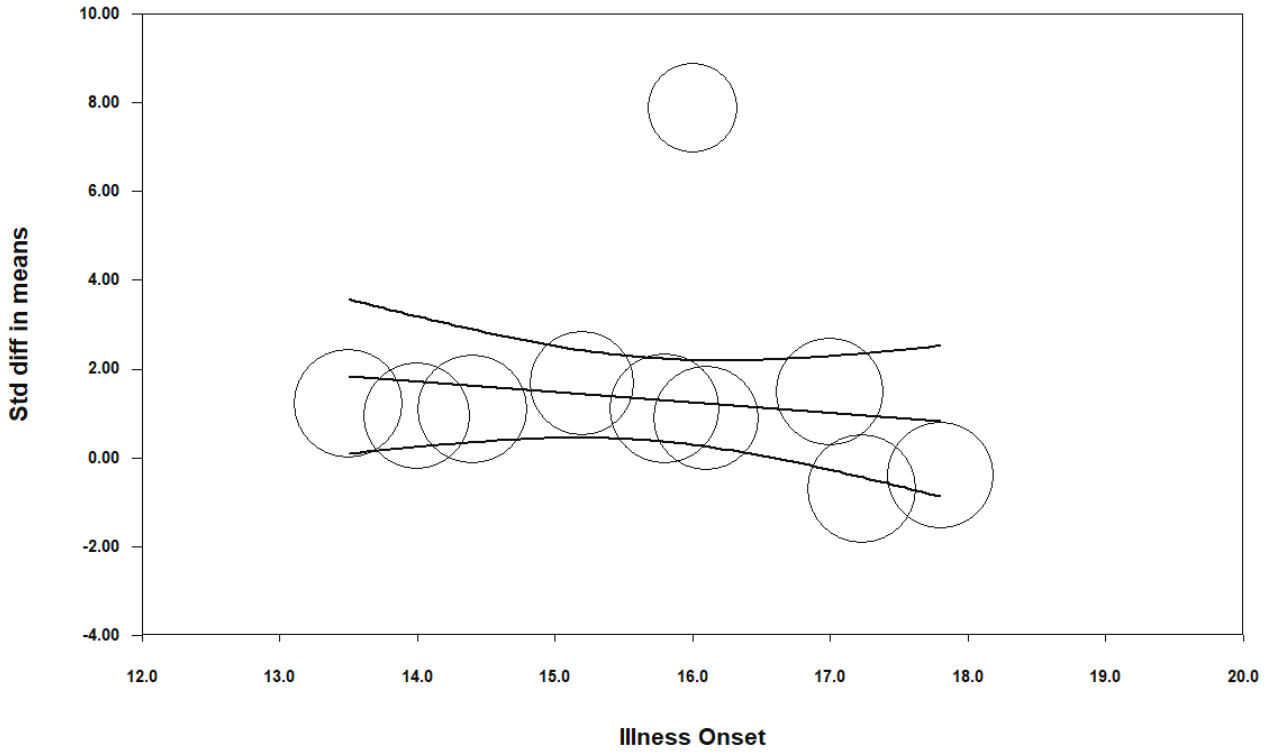

Figure H4

Regression of Standardised Difference in Means on Illness Duration